U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-260 335

THE PATUXENT RIVER. WATER QUALITY MANAGEMENT TECHNICAL EVALUATION

Federal Water Pollution Control Administration
Charlottesville, Virginia

September 1969

173210

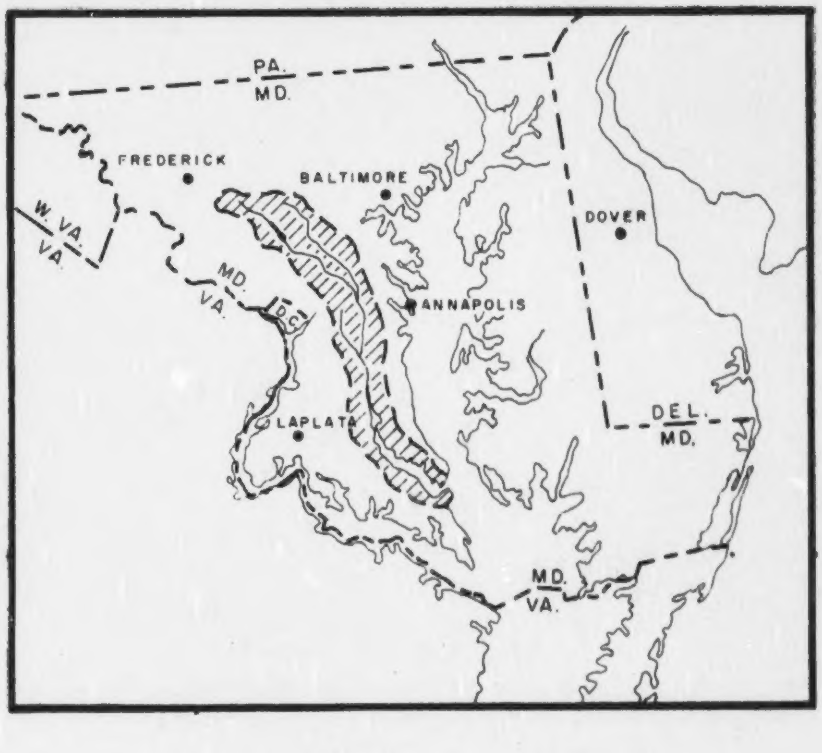
PB 260 335

PRELIMINARY-SUBJECT TO REVISION

THE PATUXENT RIVER

Water Quality Management Technical Evaluation

PRELIMINARY-SUBJECT TO REVISION


PA.
MD.
FREDERICK
BALTIMORE
DOVER
W. VA.
VA.
MD.
VA.
D.C.
ANNAPOLIS
LAPLATA
DEL.
MD.
MD.
VA.

U.S. DEPT. OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
MIDDLE ATLANTIC REGION
918 EMMET STREET
CHARLOTTESVILLE VIRGINIA
SEPTEMBER 1969

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

G

39

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-260 335

4. Title and Subtitle The Patuxent River. Water Quality Management Technical Evaluation.

5. Report Date
Sep 69

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Federal Water Pollution Control Administration,
Charlottesville, Va. Middle Atlantic Region.

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts Analysis of water quality problems of the Patuxent River Basin was made as part of the Chesapeake Bay-Susquehanna River Basins Project. A program for water quality management is presented that would maintain the interstate and intrastate water quality standards established for the Patuxent River Basin by the state of Maryland. This report emphasizes the technical aspects of water quality management in the basin. Comprehensive programs authorized by the Department of Interior are designed to improve the quality of surface and ground water supplies for industrial and recreational usage and the propagation of aquatic life.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms
Maryland
Patuxent River
*Water quality data
Chesapeake Bay
River basins
*Waste water treatment
*Waste treatment
Water resources

17c. COSATI Field/Group 13B

18. Availability Statement

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
39

22. Price

E. A. Kaeufer

FOREWORD

An analysis of water quality problems of the Patuxent River Basin was made as part of the Chesapeake Bay-Susquehanna River Basins Project. This report presents a program for water quality management which, if implemented, will maintain the interstate and intrastate water quality standards established for the Patuxent River Basin by the State of Maryland.

A study to re-examine the water and related land resource problems of the Patuxent River Basin was undertaken by the Maryland State Planning Department at the same time that the Federal Water Pollution Control Administration (FWPCA) was in the process of analyzing the water quality problems of the basin. The Maryland State Planning Department assembled a Patuxent Basin Technical Task Force to aid and help guide the study. (1) The FWPCA was invited to participate in the study as a member of the Task Force. Table A lists the Task Force members.

The findings of the cooperative effort are contained in two complementary reports; this FWPCA technical report which emphasizes the technical aspects of water quality management in the basin and the Maryland State Planning Department report, "Patuxent River, Maryland's Asset-Maryland's Responsibility," which emphasizes the water quality related land use problems within the basin and recommends institutional procedures for implementing the overall water quality management program.

Authority for participation by the Middle Atlantic Region of the FWPCA in the Patuxent River Basin water quality study is contained in Section 3(a) of the Federal Water Pollution Control Act (P.L. 84-660).

The Act authorized the Secretary of the Department of the Interior in cooperation with state water pollution control agencies to " . . . . . Prepare or develop comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries therof and improving the sanitary condition of surface and underground waters". The objective of these programs is to improve the quality of surface and ground water supplies so that they may be used for varying beneficial uses, including propagation of aquatic life, recreational and industrial uses.

The relationships developed in this cooperative effort have of inestimable value in preparing this report. The assistance and cooperation of the Patuxent River Basin Technical Task Force and its component members, collectively and individually, is herewith gratefully acknowledged.

Table A

MEMBERS OF PATUXENT BASIN TECHNICAL TASK FORCE

Maryland State Planning Department - Chairman Agency
Robert M. August
Leon Etzler

Chesapeake Biological Laboratory
Dr. Joseph A. Mihursky

Maryland Department of Forests and Parks
Edward I. Heath

Maryland Department of Game and Inland Fish
James Goldsberry

Maryland State Department of Health
Thomas D. McKewen
Alt.: Charles E. Gross

Maryland Department of Water Resources
James T. Allison
Alt.: Robert Pierce
Charles Hall

Maryland Department of Chesapeake Bay Affairs
Frederick W. Sieling
Alt.: Edgar H. Hollis

U.S. Army
Fort George G. Meade
George E. Cunningham
Alt.: Gordon Remsburg

Maryland Geological Survey
Harry Hansen

Maryland-National Capital Park and Planning Commission
Robert Arciprete
Jorge Valladares

Baltimore Regional Planning Council
Allen Leary

Maryland State Roads Commission
John Lentz

Tri-County Council for Southern Maryland
William Anders
John Mills

Washington Suburban Sanitary Commission
Dr. Algred Machis
Alt.: Stephen Profilet

Washington Metropolitan Council of Governments
Frank Price
Alt.: Dr. John J. Lentz

Chesapeake Field Station, FWPCA
U.S. Department of the Interior

Johan A. Aalto
Dr. Leo J. Hetling
Dr. Norbert A. Jaworski

Consultant to Maryland State Planning Department
Melvin E. Scheidt

TABLE OF CONTENTS

FOREWORD

Page

A. SUMMARY 1

B. CONCLUSIONS 3

C. RECOMMENDATIONS 4

Chapter

I. BASIN CHARACTERISTICS

A. DESCRIPTION I-1

B. HYDROLOGY AND CLIMATOLOGY I-3

II. WATER RESOURCES AND USE

A. WATER SUPPLY II-1

B. FISHERIES II-2

C. RECREATION II-4

III. POPULATION AND WASTEWATER PROJECTIONS

A. POPULATION STATISTICS AND GROWTH III-1

B. WASTEWATER PROJECTIONS III-4

IV. FACTORS AFFECTING WATER QUALITY

A. STUDY AREA IV-1

B. SOURCES OF POLLUTION IV-3

C. CURRENT WATER QUALITY AND TRENDS

1. Non-Tidal Waters IV-7

2. Tidal Waters IV-22

V. FRAMEWORK FOR ANALYSIS

A. WATER QUALITY STANDARDS AND IMPLEMENTATION PLANS V-1

B. INSTITUTIONAL ARRANGEMENTS V-4

TABLE OF CONTENTS (Continued)

Chapter Page

C. FLOW REGULATION POTENTIAL V-6

D. WASTEWATER TREATMENT POLICIES V-6

E. ADVANCED WASTE TREATMENT METHODS V-8

VI. WASTEWATER MANAGEMENT CONSIDERATIONS

A. WASTEWATER TREATMENT REQUIREMENTS VI-1

B. WASTEWATER MANAGEMENT SYSTEMS AND SELECTION FACTORS VI-18

C. ADVANCED WASTE TREATMENT WITH DISCHARGE WITHIN THE BASIN VI-21

D. ADVANCED WASTE TREATMENT WITH DISCHARGE TO CHESAPEAKE BAY VI-33

E. SELECTION OF A MANAGEMENT SYSTEM VI-35

VII. ADVANCED WASTE TREATMENT PROGRAM

A. PLANNING ALTERNATIVES VII-1

B. REVIEW OF ALTERNATIVE PLANS VII-9

BIBLIOGRAPHY VIII-1

APPENDICES

A. FIGURES A-1

B. TABLES B-1

C. COST ANALYSIS C-1

LIST OF TABLES

Number	Description	Page
I-1	Mean Monthly Precipitation and Air Temperatures	I-4
I-2	Mean Annual Air Temperatures, Precipitation, and Snowfall for Selected Weather Stations	I-5
I-3	Surface Water Runoff Summary for Selected Stations	I-6
II-1	Major Surface Water Withdrawals	II-1
II-2	Resident Fishing and Hunting Licenses	II-5
II-3	Current Monetary Assessment of Water and Land Related Resources	II-7
III-1	Population Projections for Baltimore, Maryland and Washington, D.C.	III-1
III-2	Population Trends and Projections Patuxent River Basin	III-2
III-3	Projected Wastewater Volumes and Loadings	III-5
IV-1	Zone Description	IV-1
IV-2	1967 Operating Data for the Major Wastewater Treatment Plants	IV-4
V-1	Designated Water Uses for Various Water Zones in the Patuxent River Basin	V-3
VI-1	Phosphorus Removal Requirements	VI-4
VI-2	Nitrogen Removal Requirements	VI-5
VI-3	Projected BOD Loadings	VI-7
VI-4	Projected BOD Loadings by Zone	VI-9
VI-5	Projected BOD and Nitrogen Removal Requirements by Zones	VI-14
VI-6	Oxygen Demanding Material Requirements	VI-15

LIST OF TABLES (Continued)

Number	Description	Page
VI-7	Population Projections for Lower Patuxent Basin	VI-16
VI-8	Wastewater Treatment Plants, Existing, Proposed, and under Construction in Lower Patuxent River Basin	VI-17
VI-9	Cost Disposal to Chesapeake Bay	VI-20
VI-10	Current Design Capacity and Summary of Projected Wastewater Volumes for the Years 1980, 2000, and 2020 Upper Patuxent River Basin	VI-22
VI-11	Alternate Wastewater Treatment Systems	VI-27
VI-12	Cost Summary of Modular Units for Plan A for Wastewater Treatment	VI-29
VI-13	Cost Summary of Modular Units for Plan B for Wastewater Treatment	VI-30
VI-14	Cost Summary of Modular Units for Plan C for Wastewater Treatment	VI-31
VI-15	Cost Summary of Modular Units for Plan D for Wastewater Treatment	VI-32
VI-16	Plan E, Cost of Disposal to Chesapeake Bay	VI-33
VII-1	Cost Comparisons of Various Modular Sequences with Disposal within the Basin	VII-3
VII-2	Cost Summary of Alternative Plans	VII-4
VII-3	Subjective Evaluation of Water Quality Management Alternatives	VII-7
VII-4	Compendium of Various Alternatives	VII-9
VII-5	Plan B-1	VII-11

LIST OF TABLES (Continued)

Number	Description	Page
	APPENDIX TABLES	
B-1	Patuxent River - Survey Station Locations	B-2
B-2	Patuxent Estuary - Survey Station Locations	B-4
B-3	Mean Monthly and Design River Flows, USGS Gage	B-5
B-4	Mean Monthly and Design River Flows, Selected Stations	B-6
B-5	Oysters, Softshell Clams, and Crabs Harvested by County	B-7
B-6	Wastewater Service Area Projections	B-8
B-7	Waste Loading Projections for Service Areas	B-10
B-8	County Population Projections	B-14
B-9	Inventory of Wastewater Discharges	B-15
B-10	Summary of Stream Survey Data, Patuxent River, July-August, 1955	B-20
B-11	Summary of Stream Survey Data, Patuxent River, March, 1967	B-21
B-12	Summary of Stream Survey Data, Little Patuxent River, March, 1967	B-24
B-13	Summary of Stream Survey Data, Patuxent River, July-August, 1967	B-25
B-14	Summary of Stream Survey Data, Little Patuxent River, July-August, 1967	B-27
B-15	Summary of Stream Survey Data, Patuxent River, September, 1967	B-29
B-16	Summary of Stream Survey Data, Little Patuxent River, September, 1967	B-31
B-17	Summary of Stream Survey Data, Patuxent River, October, 1967	B-33

LIST OF TABLES (Continued)

APPENDIX TABLES (Con't)

Number	Description	Page
B-18	Summary of Stream Survey Data, Little Patuxent River, October, 1967	B-35
B-19	Recent and/or Current Water Quality Surveys	B-37
B-20	Means and Extremes, Surface Water Temperatures, Patuxent Estuary	B-39
B-21	Potential Storage Locations, Middle Patuxent Basin	B-40
B-22	Low Flow Augmentation Potential Patuxent Basin	B-41
C-1	Plans A, B, C, and D, Secondary System Modular Cost for the Years 1970-2000	C-2
C-2	Plan A - Coagulation and Sedimentation Modular Cost for the Years 1970-2000	C-4
C-3	Plan A - Ammonia Stripping Modular Cost for the Years 1970-2000	C-6
C-4	Plan A - Rapid Sand Filtration Modular Cost for the Years 1970-2000	C-8
C-5	Plan A - Grandular Carbon Adsorption Modular Cost for the Years 1970-2000	C-10
C-6	Plan B - Coagulation and Sedimentation Modular Cost for the Years 1970-2000	C-12
C-7	Plan B - Ammonia Stripping Modular Cost for the Years 1970-2000	C-14
C-8	Plan B - Rapid Sand Filtration Modular Cost for the Years 1970-2000	C-16
C-9	Plan B - Grandular Carbon Adsorption Modular Cost for the Years 1970-2000	C-18
C-10	Plan C - Coagulation and Sedimentation, Ammonia Stripping, Rapid Sand Filtration, and Grandular Carbon Adsorption Modular Cost for the Years 1970-2000	C-20

LIST OF TABLES (Continued)

Number	Description	Page
	APPENDIX TABLES (CON'T)	
C-11	Plan D - Coagulation and Sedimentation, Ammonia Stripping, Rapid Sand Filtration, and Grandular Carbon Adsorption Modular Cost for the Years 1970-2000	C-22
C-12	Cost of Connecting Interceptors for Plans	C-23
C-13	Bay Outfall Interceptor and Pumping Costs	C-24

LIST OF FIGURES

Number	Description	Page
I-1	Map - Patuxent River Basin	I-2
III-1	Population Projections, Cities and Counties	III-3
IV-1	Map - Survey Station Locations	IV-2
IV-2	Water Quality Comparison, 1955, 1961, 1966	IV-9
IV-3	Observed DO Profiles 1967	IV-11
IV-4	Observed Temperature, DO and BOD Data, 1967	IV-12
IV-5	DO Distribution for Station 8	IV-14
IV-6	Observed Temperature, DO, BOD Data, Little Patuxent River	IV-15
IV-7	Observed TKN, PO_4 and BOD Profiles, 1967	IV-16
IV-8	Computed Phosphate Profiles and Stream Survey Data, 1967	IV-18
IV-9	Observed TKN and NO_2-NO_3 Profiles, 1967	IV-20
IV-10	Nitrification Study	IV-21
IV-11	Observed Water Quality Data, Patuxent Estuary at Lower Marlboro	IV-24
IV-12	Observed Water Quality Data, Patuxent Estuary at Lower Marlboro, 1962, 1964, 1966, 1967	IV-25
IV-13	Observed Water Quality Data, Patuxent Estuary, 1964, 1966, 1967	IV-26
IV-14	Patuxent River Estuary, Chlorophyll and Turbidity, NRI	IV-28
IV-15	Patuxent Estuary Nutrient Survey, CFS	IV-29
V-1	Proposed Modular Sequences for Advanced Waste Treatment	V-10
VI-1	Projected PO_4 Concentration Entering the Patuxent Estuary	VI-3

LIST OF FIGURES (Continued)

Number	Description	Page
VI-2	Projected Inorganic Nitrogen Concentration Entering the Patuxent Estuary	VI-6
VI-3	Wastewater Treatment Removal Zones	VI-8
VI-4	BOD_5 - Nitrogen Loadings in Zone I	VI-10
VI-5	BOD_5 - Nitrogen Loadings in Zone II	VI-11
VI-6	BOD_5 - Nitrogen Loadings in Zone III	VI-12
VI-7	Plan A	VI-23
VI-8	Plan B	VI-24
VI-9	Plan C	VI-25
VI-10	Plan D	VI-26
VI-11	Plan E	VI-34

APPENDIX A - FIGURES

A-1	Unregulated Mean Monthly and Design Flows
A-2	Annual Flow Duration Curves
A-3	Wastewater Service Areas
A-4	Schematic of Mathematical Model
A-5	Monthly Uniform Use Rate WCCS Reservoirs

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. Summary

1. The Patuxent River Basin, with its 930 square mile drainage area, lies between the rapidly expanding metropolitan areas of Washington, D.C. and Baltimore, Maryland. In several areas of the basin, forests and farm lands are giving way to suburban communities with greatly increased demands for roads, electrical utilities, water services and sewerage systems.

2. The predominantly pastoral character of the basin has been preserved up to the present time largely due to the light impact which the limited industry in the basin has had on the natural environment and the virtual absence of large scale intensive agriculture.

3. Out of a total of from 45 to 55 million gallons of daily water supply withdrawals from non-estuarine surface waters of the basin for domestic use, 40 million gallons of water is diverted to Washington, D.C., outside the basin. Most of the 730 million gallons of surface water withdrawn daily from the Patuxent Estuary for industrial use is for cooling purposes.

4. The Patuxent Estuary is a valuable natural resource for the commercial harvesting of several species of fin and shellfish including clams, oysters, and crabs. In addition, the estuary is used extensively for recreational purposes such as sport fishing and boating. Commercial harvesting of the fishery resource in the estuary and the recreational use made of the estuary provide the basis for an estimated income of approximately $500,000 and $6,500,000 annually.

5. Water quality standards have been adopted for the non-estuarine intrastate waters and estuarine interstate waters of the basin. An implementation plan has been adopted by the State of Maryland, and in the case of interstate waters, approved by the Secretary of the Department of the Interior for the implementation and enforcement of the water quality standards.

6. At the present time, water quality standards for the Patuxent River Basin are not being met in a 20 mile reach below Laurel, Maryland. High coliform densities and dissolved oxygen concentrations less than 4.0 mg/l are often observed in this reach even though 85 percent or better 5-day biochemical oxygen demand* (BOD) removal is provided by almost all the major sewage treatment facilities within the basin.

7. Eight municipal waste treatment facilities along a 30 mile reach in the middle portion of the river have a combined discharge of 10 million gallons per day (mgd) and contribute over 97 percent of the total treated municipal wastewater discharged within the basin. A thermal electric generating station which discharges 720 mgd of cooling water into the Patuxent Estuary is the only significant industrial water use in the basin.

8. The growth in population and the volume of wastewater produced within the basin are projected to increase rapidly through the year 2020. The population is projected to grow from the 1967 level of 230,000 to 1,131,000 by 2020. The volume of wastewater produced within the basin

* The BOD test is used to determine the pollutional strength of domestic and industrial wastes in terms of the oxygen required if discharged into natural watercourses in which aerobic conditions exist.

is projected to grow from a 1967 level of 11 to 117 mgd by 2020.

9. Preliminary survey data indicate that cooling water discharged into the Patuxent Estuary is not raising water temperatures to exceed the water quality standards. Long term studies are currently being conducted to determine the possible future effects of thermal discharges on the estuarine ecosystem.

B. Conclusions

Based upon extensive water quality surveys in the river and data analysis, the following conclusions have been reached:

1. The middle reach of the Patuxent River is unable to assimilate the current level of treated wastes (85 percent or better removal of 5-day BOD) without serious contravention of water quality standards during low flow periods.

2. Treated waste discharges have also caused increasing concentrations of nutrients, particularly phosphates and nitrates, in the middle reaches of the basin and upper estuary. The continued discharge of wastes receiving only secondary treatment will result in accelerated eutrophication, with dissolved oxygen levels below the water quality standard and greatly increased phytoplankton productivity. Excessive algal blooms have been observed recently in the upper estuary.

3. The lower portion of the estuary has already experienced a slight increase in nutrients attributable to treated waste discharges into the waters of the upper basin. However, there have been no noticeable adverse effects to date from this condition.

4. To achieve dissolved oxygen standards in the middle reach of the Patuxent River Basin, a high degree of both carbonaceous and nitrogenous BOD removal is required. Loading rates for various zones of the basin have been established.

5. To reduce effectively the nutrient input and maintain a balanced ecosystem in the Patuxent Estuary, a high degree of phosphorus and nitrogen removal will also be required.

6. Of the various alternative combinations of flow regulation and/or wastewater treatment investigated to meet the high removal requirements, it appears that the comprehensive approach to water quality management in the Patuxent River Basin is wastewater renovation by advanced wastewater treatment.

7. Based on cost considerations, flexibility to take advantage of possible technological developments, tangible and intangible benefits, the alternative of secondary treatment followed by advanced wastewater treatment facilities at four locations (Plan B) appears to be preferable.

C. Recommendations

1. Since the water quality conditions in the Patuxent River Basin are under increasing stress from population growth, it is recommended that cooperative planning action be initiated immediately to alleviate current degraded conditions and to develop a sound plan for the enhancement of the waters of the basin.

2. Provision of advanced waste treatment in one of the alternative plans suggested will be necessary to achieve adopted water quality standards in the immediate future. Adoption of a program for providing

a staged sequence in advanced treatment is recommended. The indicated system will consist of four modular processes: (a) coagulation and sedimentation, (b) ammonia stripping, (c) rapid sand filtration, and (d) granular carbon adsorption. Each stage of the complete treatment system is a modular unit and can be added as the need for additional treatment arises.

3. The Maryland State Planning Department in July, 1968, published a report on the Patuxent River Basin entitled, "The Patuxent River, Maryland's Asset - Maryland's Responsibility." The report recommends the creation of a Patuxent River Basin Advisory Committee and a Patuxent River Basin Council. The advisory committee, if established as recommended, would be the agency through which a basin-wide water quality program could be developed and subsequently implemented.

4. If Maryland Waste Acceptance Service is adopted it is recommended that the Waste Acceptance Service assume primary responsibility for formulating a water quality management program for the Patuxent River Basin.

CHAPTER I

BASIN CHARACTERISTICS

A. DESCRIPTION

The Patuxent River Basin with a drainage area of 930 square miles, is the largest river basin located entirely in the State of Maryland (Figure I-1). The headwaters of the Patuxent River are located in the Piedmont area of Howard and Montgomery Counties, from which the river flows in a southeasterly direction 110 miles before entering Chesapeake Bay. The river basin lies between the metropolitan areas of Washington, D.C. and Baltimore, Maryland, and forms a boundary for Howard, Montgomery, Prince Georges, Anne Arundel, Calvert, St. Mary's and Charles Counties.

The narrow swift streams in the Piedmont physiographic province widen and become sluggish as they cross the Fall Line and enter the Coastal Plain province in the area of the communities of Laurel and Savage. Below the Fall Line, the river becomes progressively wider and more sluggish until it enters the Patuxent Estuary.

The Patuxent River Estuary is characterized by tidal influence and salinity where the river blends with the bay. The estuary extends upstream from Chesapeake Bay to near Hardesty, a distance of about 56 miles. During low flow periods increased salinity has been detected 43 miles upstream at Lyons Creek.

The Little Patuxent and Western Branch which have drainage areas of 160 and 110 square miles are the two major tributaries of the Patuxent River. The Little Patuxent has a major tributary, the Middle Patuxent, which has a drainage area of 57 square miles.

Reproduced from best available copy.

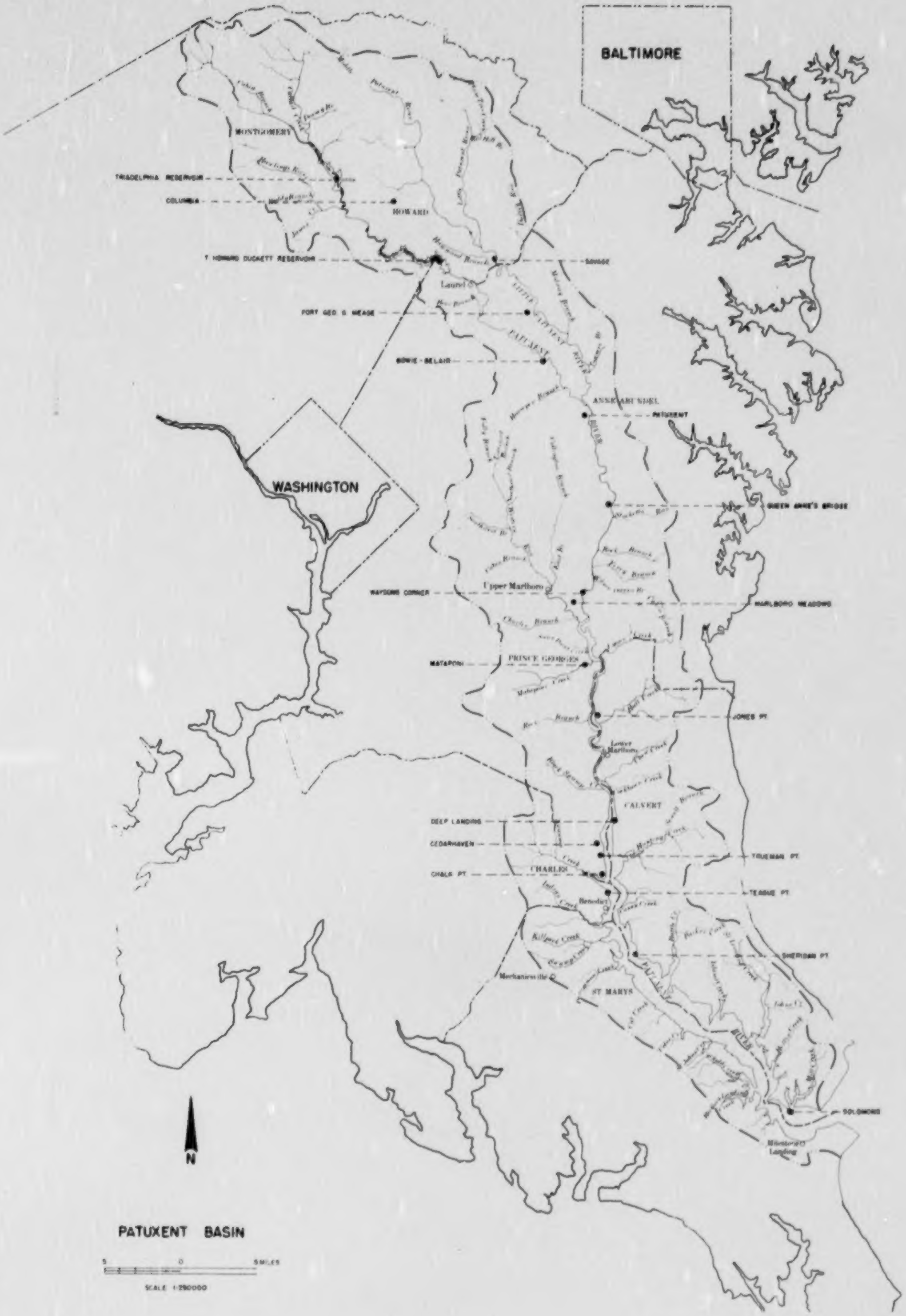

BALTIMORE
WASHINGTON
MONTGOMERY
HOWARD
ANNE ARUNDEL
PRINCE GEORGES
CALVERT
CHARLES
ST MARYS
TRIADELPHIA RESERVOIR
COLUMBIA
T HOWARD DUCKETT RESERVOIR
SAVAGE
Laurel
FORT GEO G MEADE
BOWIE - BELAIR
PATUXENT
QUEEN ANNE'S BRIDGE
WAYSONS CORNER
Upper Marlboro
MARLBORO MEADOWS
MATAPONI
JONES PT
Lower Marlboro
DEEP LANDING
CEDARHAVEN
TRUEMAN PT
CHALK PT
TEAGUE PT
Benedict
SHERIDAN PT
Mechanicsville
SOLOMONS
Millstone Landing
LITTLE PATUXENT RIVER
PATUXENT RIVER
N
PATUXENT BASIN
5 0 5 MILES
SCALE 1:250000

FIGURE I-1

B. HYDROLOGY AND CLIMATOLOGY

The hydrology and climatology of the basin are both under a combination of continental and maritime influences. Climatologic and hydrologic parameters are monitored at 20 U.S. Weather Bureau stations and at 10 U.S. Geological Survey stations (Appendices A-1, A-2).

The mean annual air temperature within the basin ranges from 57.5°F at Solomons to 54.6°F at Laurel. The mean monthly air temperature at Laurel varies from a low of 33.7°F in January to a high of 75.9°F in July. The effect of Chesapeake Bay on air temperature is indicated by the two or three degree increase in temperature at Solomons. Mean annual air temperatures for selected area stations in the basin are presented in Table I-1.

The total annual precipitation in the basin and surrounding area varies from about 39 to 44 inches per year with the maximum precipitation occurring in July and August. The mean annual snowfall ranges from 25 inches in the northern counties of the basin to about 15 inches in the southern counties demonstrating the effect of Chesapeake Bay on the hydrology of the basin. Additional snowfall data are contained in Table I-2.

The mean surface-water yield in the basin varies from a minimum of 0.812 cfs/square mile in the main stem of the Patuxent River at Laurel to a maximum of 0.894 cfs/square mile in the Little Patuxent at Savage. Data on seven day, ten year low flows is presented in Table I-3.

Data on the monthly variation in flow throughout the river system were compared with the seven day, ten year low flow design criteria of

Table I-1

MEAN MONTHLY PRECIPITATION AND AIR TEMPERATURES
FOR
LAUREL AND SOLOMONS, MARYLAND

Month	Precipitation		Temperature	
	Laurel (inches)	Solomons (inches)	Laurel (Deg.F)	Solomons (Deg.F)
January	3.17	3.09	33.7	36.9
February	2.83	2.85	34.5	37.2
March	3.63	3.36	43.0	45.0
April	3.67	3.22	53.3	54.7
May	3.58	3.29	63.3	65.4
June	3.86	3.31	71.5	73.8
July	4.31	4.76	75.9	78.4
August	4.55	4.34	74.0	77.2
September	3.36	2.99	68.1	71.7
October	3.07	2.76	56.5	60.7
November	2.73	2.54	45.6	49.4
December	3.14	2.78	35.6	39.4
Annual	41.90	39.29	54.6	58.3

Table I-2

MEAN ANNUAL AIR TEMPERATURES, PRECIPITATION, AND SNOWFALL FOR SELECTED WEATHER STATIONS

Station	Years of Record	Mean Precipitation (inches)	Years of Record	Mean Temperature (Deg.F)	Years of Record	Mean Snowfall (inches)
Annapolis Naval Academy	89	43.55	94	55.9	63	19.2
Baltimore Airport	13	43.41	12	55.7	12	18.4
Frederick Airport	13	39.16	13	53.9	13	17.7
Ft. George G. Meade	19	43.96	18	54.7	18	16.9
Laurel	63	41.90	60	54.6	--	--
Solomons	69	39.29	67	57.5	--	--
Westminster	50	43.36	50	53.5	48	28.5

Table I-3

SURFACE WATER RUNOFF SUMMARY FOR

SELECTED STATIONS

Station Number	Location	River Mile (From Mouth)	Drainage Area (Sq.Mile)	Mean Flow cfs	Mean Flow cfs/sq.mile	7-day, 10-year cfs	7-day, 10-year cfs/sq.mile
16	Above Laurel	80.9	133	108	.812	9.2	.069
10	Below Bowie	63.8	181	147	.812	12.6	.069
L7*	Below Savage	81.4	98	88	.897	12.0	.122
L1*	Below Bowie	63.8	161	144	.894	19.6	.121
9	Below Bowie	63.6	342	291	.850	32.2	.094
5	Wayson's Corner	47.5	414	349	.842	38.8	.093
4A	Below Western Branch	45.0	525	436	.830	43.5	.082

* L denotes Little Patuxent River. For further description of sampling stations, see Appendix A-1 and A-2.

the State of Maryland in order to compute the design discharge data and flow augmentation requirements for treatment facilities. It was determined that the seven-day low-flow design criteria used by the State of Maryland was interchangeable with the thirty-day, twenty-year low-flow design criteria used in the mathematical model for predicting the effect of different waste loads on watercourses. This determination was based on data from the Patuxent River and by analogy to other rivers with similar characteristics in the Middle Atlantic States.

Approximately 109 cfs or twenty-five percent of the 436 cfs mean annual flow to the Patuxent Estuary (Figure I-1) originates in the upper Patuxent River watershed controlled by two reservoirs owned by Washington Surburban Sanitary Commission (WSSC). The combined storage capacity of the Tridelphia and T. Howard Duckett Reservoirs is 12.5 billion gallons of water. From 1960 to the present, the average annual water use by WSSC from the Tridelphia and T. Howard Duckett Reservoirs has varied from 65 to 75 cfs. About 93 percent of the water withdrawn from the reservoirs is transported outside the basin.

CHAPTER II

WATER RESOURCES AND USE

A. WATER SUPPLY

Of the approximately 15 mgd of water used for non-industrial-cooling purposes in the Patuxent River Basin approximately two-thirds is used for domestic use and the remainder for industrial use. In addition, about 40 to 50 mgd of water is transported for domestic purposes to the Washington, D.C. metropolitan area outside of the basin by WSSC.

An average of 500,000 gpm* of saline water is used for cooling at the Potomac Electric Power Company Chalk Point thermal electric generating station. The Chalk Point facility is the largest single water used in the basin.

Most of the water used for industrial and municipal purposes within the basin is derived from four surface sources. The following table lists the agency responsible for withdrawing surface water, the quantity of water withdrawn, and the surface water source.

Table II-1

MAJOR SURFACE WATER WITHDRAWALS

Utility	Quantity (mgd)	Source
Washington Suburban Sanitary Commission	40-50	T.H. Duckett and Tridelphia Reservoirs
Fort George G. Meade	3.1	Little Patuxent River
Maryland House of Correction	0.8	Little Patuxent River and Dorsey Run
PEPCO Chalk Point Plant	720	Patuxent Estuary

*Gallons per minute

The remaining water requirements are obtained from ground water sources and are estimated to be about 5 mgd (3). An insignificant amount of water is used for agricultural purposes.

B. FISHERIES

1. Finfish

The Patuxent River Basin supports a substantial commercial fishing industry. There are approximately 160 species of fish in the Patuxent River Basin exosystem of which the anadromous* and semi-anadromous** species such as striped bass, shad, white and yellow perch, hickory shad, winter flounder, and herring are the most economically significant.

Another group of commercially important species spawns and winters outside of Chesapeake Bay and utilizes the Patuxent Estuary for a nursery area and feeding ground. Included in this group of fish are the croaker, spot, silver perch, seatrout, and drum.

The annual commercial harvest from the Patuxent Estuary has varied from 100,000 pounds in 1965 to 800,000 pounds in 1951. The dockside value of the average annual harvest has been estimated to be $120,000.

* Anadromous - fish which spend most of their lives in the ocean and ascend fresh water streams and rivers to spawn.

** Semi-anadromous - fish which spend most of their lives in a brackish water and ascend fresh water streams to spawn.

2. Oysters

Oysters are indigenous to the lower half of the Patuxent Estuary. Approximately 14,800 acres out of a total of 27,000 acres in the lower half of the estuary are capable of oyster production (1).

The Patuxent Estuary is considered prime shellfish water, yielding oysters "fat" and outstanding in quality. In only one section, about 5 acres near Solomons Island Harbor, is harvesting restricted due to high bacteriological counts in the estuary.

Table B-5 presents the annual production and volume of the oysters harvested in the Patuxent Estuary since the 1963-1964 period.

Assuming the yield is to be about 300 bushels per acre (only one-tenth that of some areas of record) for the 14,800 acres currently being utilized in the Patuxent Estuary, the yield could conceivably be 4,400,000 bushels with a dockside value of $17,000,000 (1).

3. Clams

Soft clams, like oysters, have been idigenous to Chesapeake Bay and occur in the same general areas. Only in recent years, however, have they been harvested commercially and the resource far exceeds the demand. The Maryland Department of Chesapeake Bay Affairs (MDCBA) is making an effort to promote a market for the potential yield of 46,000 bushels annually at an estimated value of $40,000 (1).

4. Crabs

The lower Patuxent Estuary is a favorable habitat for the growth of blue crabs. As juveniles, the young crabs feed and grow in the estuary before completing their life cycle at the mouth of the bay.

The annual harvest of crabs; hardshell, softshell and peelers, was about 700,000 pounds in 1966 with a dockside value of around $48,000 (Appendix B-5). Recreational fishermen in the Patuxent Estuary in 1963 caught an estimated 43,000 pounds of crabs.

C. RECREATION

Recreational activities in the Patuxent River Basin include: fresh and tidal sport fishing, boating, hunting, swimming and picnicking.

1. Tidal Sport Fishing

Studies of sport fishing in the Patuxent Estuary have been made by Elser and by Sheare, et.al. (4,5). Based on their findings, it has been estimated that over 71,000 fishing trips were made to the estuary in 1963 from which fisherman obtained about 180,000 pounds of fish. Excluding the cost of the boats and permanent tackle, the annual expenditure for sport fishing in the estuary was estimated to be about $500,000 in 1963 (1).

Recreational fishing studies as reported by Hollis (1) have indicated a 5 to 7 percent annual increase in the recreational activities in this area. It has been projected that by 1980 over 200,000 fishing trips will be made to the estuary annually with expenditures well over $1,000,000.

2. Fresh Water Fishing and Hunting

An estimated 35,000 fresh water fishermen in the vicinity of the Patuxent River Basin spend over $3,000,000 annually on equipment and supplies related to fishing. Table II-2 gives the statistics on fishing and hunting licenses.

Table II-2

RESIDENT FISHING AND HUNTING LICENSES*
1966 - 1967

County	Fishing License Sales	County Resident Hunting License Sales
Howard	1,049	781
Montgomery**	15,253	3,139
Anne Arundel	6,439	4,094
Charles**	718	2,989
St. Marys**	829	2,636
Calvert	104	1,491
Prince Georges**	12,101	3,930
	36,493	19,060

* Source: Maryland Department of Game and Inland Fish

** Note: Fishing probably divided between Patuxent and Potomac River watersheds

The 19,060 resident hunters in the Patuxent River Basin spend approximately $1.5 million each year on their sport. The above spending does not include those who are not required to purchase a license nor those who purchased a statewide hunting permit.

3. Boating

At the present time there are about 22 marine facilities in the Patuxent Estuary primarily between Solomons Island and Benedict. These marinas offer slips and moorings to accommodate about 900 boats, launching areas for small boats, and boat rentals. Of the 29,000 pleasure boats in the State of Maryland, approximately 2,700 are harbored in the Patuxent Estuary. An annual expenditure for pleasure boating in the Patuxent Estuary has been estimated to be $1,000,000 (1).

4. Swimming, Picnicking, etc.

While there are limited public recreational areas in the estuary, there are numerous small private areas which are used for such recreational pursuits as swimming and picnicking. Scuba diving has attracted a large number of participants interested in sport fishing, oystering and clamming. The lower Patuxent areas are becoming increasingly attractive for permanent and summer homes for many Washington, D.C. area workers (1).

Current monetary assessment of water and land related resources in the Patuxent River Basin is presented in Table II-3.

Table II-3

CURRENT MONETARY ASSESSMENT OF WATER AND LAND RELATED RESOURCES PATUXENT RIVER BASIN

Uses	Annual Dollar Value
Water Supply	
Municipal	Undetermined
Industrial	Undetermined
Agricultural	None
Commercial Fishing	
Fin Fish	$ 120,000*
Oysters	300,000*
Softshell Clams	6,000*
Crabs	48,000*
	$ 474,000
Recreation	
Sport Fishing - Tidal	1,000,000**
Sport Fishing - Non-tidal	3,000,000**
Hunting	1,500,000**
Pleasure Boating	1,000,000
Swimming, Picnicking	Undetermined
Total	6,500,000

---

* Dockside value from Table V-2

** Annual expenditures

Source - Appendices, Ref. (1)

CHAPTER III

POPULATION AND WASTE WATER PROJECTIONS

A. POPULATION STATISTICS AND GROWTH

The population of the Patuxent River Basin increased from 35,000 in 1940 to over 134,000 in 1960. The rapid growth of population in the basin resulted primarily from the rapid outward expansion of suburban development between the Baltimore and Washington areas. For example, in the period from 1940 to 1956 Prince Georges, Montgomery and Anne Arundel Counties were ranked third, fourth and thirteenth among the fastest growing SMSA counties in the United States.

The growth of the Standard Metropolitan Statistical Areas (SMSA) of Baltimore and Washington are presented below in Table III-1.

Table III-1

POPULATION PROJECTIONS FOR BALTIMORE, MARYLAND
AND WASHINGTON, D.C.

	1960	1965	1980	2000	2020
Baltimore, Md.	1,727,023	1,829,700	2,400,000	3,000,000	3,700,000
Washington, D.C.	1,989,377	2,424,685	3,300,000	4,000,000	5,200,000
Total	3,716,400	4,254,385	5,700,000	7,000,000	8,900,000

The National Planning Association (NPA) developed the county and SMSA population projections for the Patuxent River Basin area as part of an overall economic base study for the Chesapeake Bay drainage area. Population projections developed by the Maryland State Planning Department (MSPD) are almost identical to NPA's projections for the Baltimore SMSA.

The county is the basic geographic unit used in this study for wastewater load projections. Population projections from both the NPA and MSPD were used in developing the wastewater load projections.

Each county within the basin was divided into wastewater service areas (Appendix Figure A-3). Service area designations were based on the following: the Patuxent Regional Sewerage Report of 1961 (26), water and sewerage master plans for Howard and Anne Arundel Counties (27), (28) and current waste discharge points.

A summary of the basin population trends and projections is given below in Table III-2 and in Figure III-1.

Table III-2

POPULATION TRENDS AND PROJECTIONS,*
PATUXENT RIVER BASIN

Year	Population
1940	35,000
1950	52,000
1960	134,000
1967	230,000
1980	400,000
2000	670,000
2020	1,131,000

* The part of Montgomery County served by the Washington, D.C. facility is excluded.

POPULATION PROJECTIONS

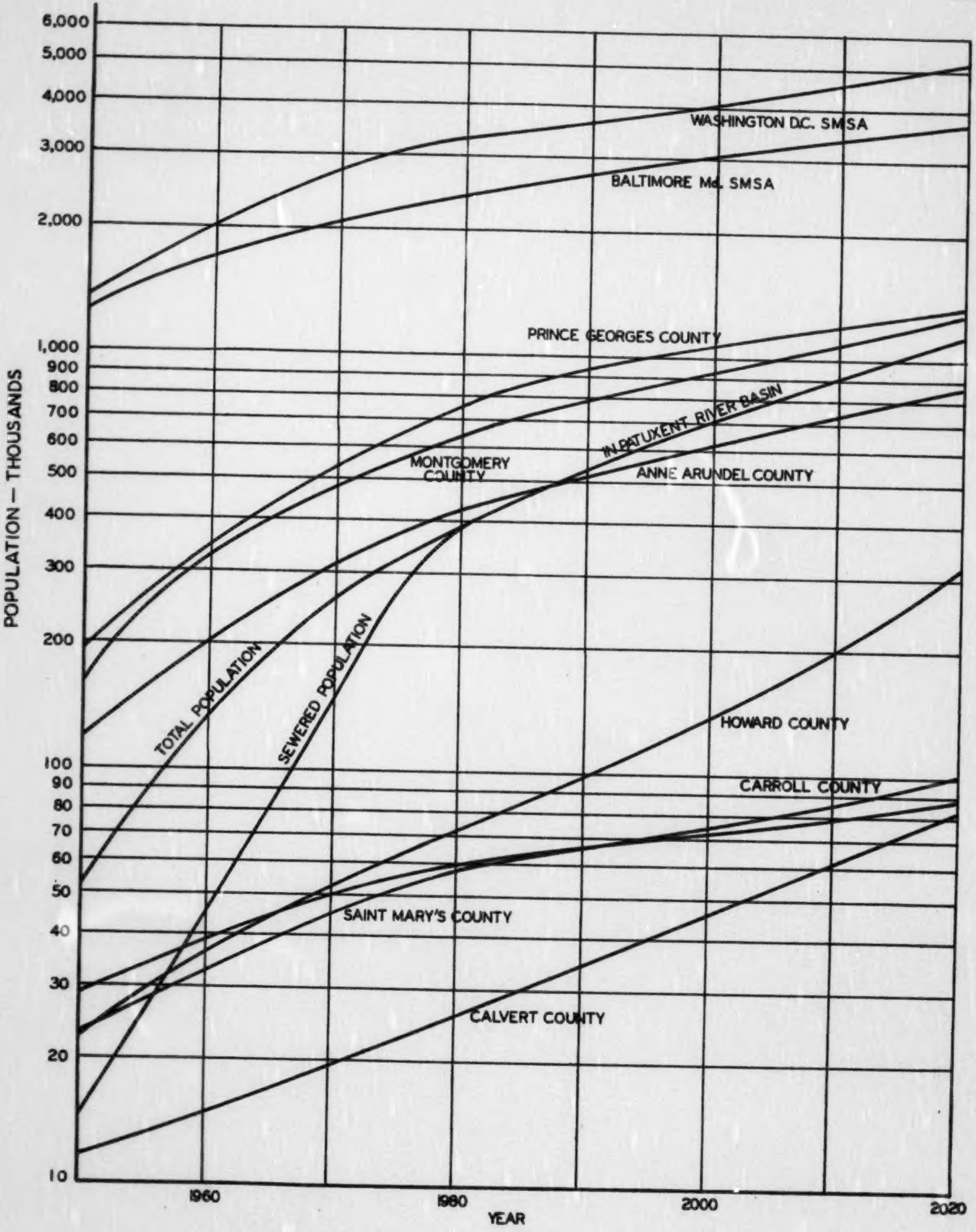


FIGURE III-1

The projections for the individual wastewater service areas are presented in Table B-6.

B. WASTEWATER PROJECTIONS

Wastewater service areas were divided to reflect current and future discharge points. The waste loads from Maryland City were distributed between the existing Maryland City and Maryland House of Correction plants; and the Fort Meade loads, between existing plants Nos. 1 and 2. The waste loads from Bowie-Horsepen and U.S. Government land were combined into one discharge near the confluence of Horsepen Branch.

Current flow rates and BOD loadings (Table B-7) from each waste treatment facility were used in projecting future waste volumes and loads. It was assumed for the purpose of projecting waste loads that the population served by public sewers would be the same population residing in water service areas. The populations of the Patuxent River Basin to be served by municipal waste treatment facilities, waste volumes, and BOD Loadings for the year 1967 and the design years are presented in Table III-3.

Table III-3

PROJECTED WASTEWATER VOLUMES AND LOADINGS

Year	Population Served	Waste Volumes (mgd)	BOD Loadings (lbs/day)	Total* Phosphorus as PO4 (lbs/day)	Total** Kjeldahl Nitrogen as N (lbs/day)
1967	118,000	11	17,400	2,500	1,200
1980	400,000	41	64,300	8,700	5,400
2000	670,000	68	101,400	14,300	9,400
2020	1,131,000	117	178,700	24,400	15,300

* Based on 1967 waste treatment effluent sampling data, the phosphorus data presented above are projected as a linear function of population.

** Based on a 1966-1967 sampling survey of 20 wastewater plants in the Potomac and Patuxent Basins (34). Average effluent of TKN as N concentration of 17.0 mg/1.

CHAPTER IV

FACTORS AFFECTING WATER QUALITY

A. STUDY AREA

For purposes of analysis, the Patuxent River Basin has been divided into three regions: upper, the area above the Fall Line; middle, the area below the Fall Line to Wayson's Corner; and lower, the estuary or tidal portion of the basin. The middle and lower regions have been further sub-divided into four zones, as follows:

Table IV-1

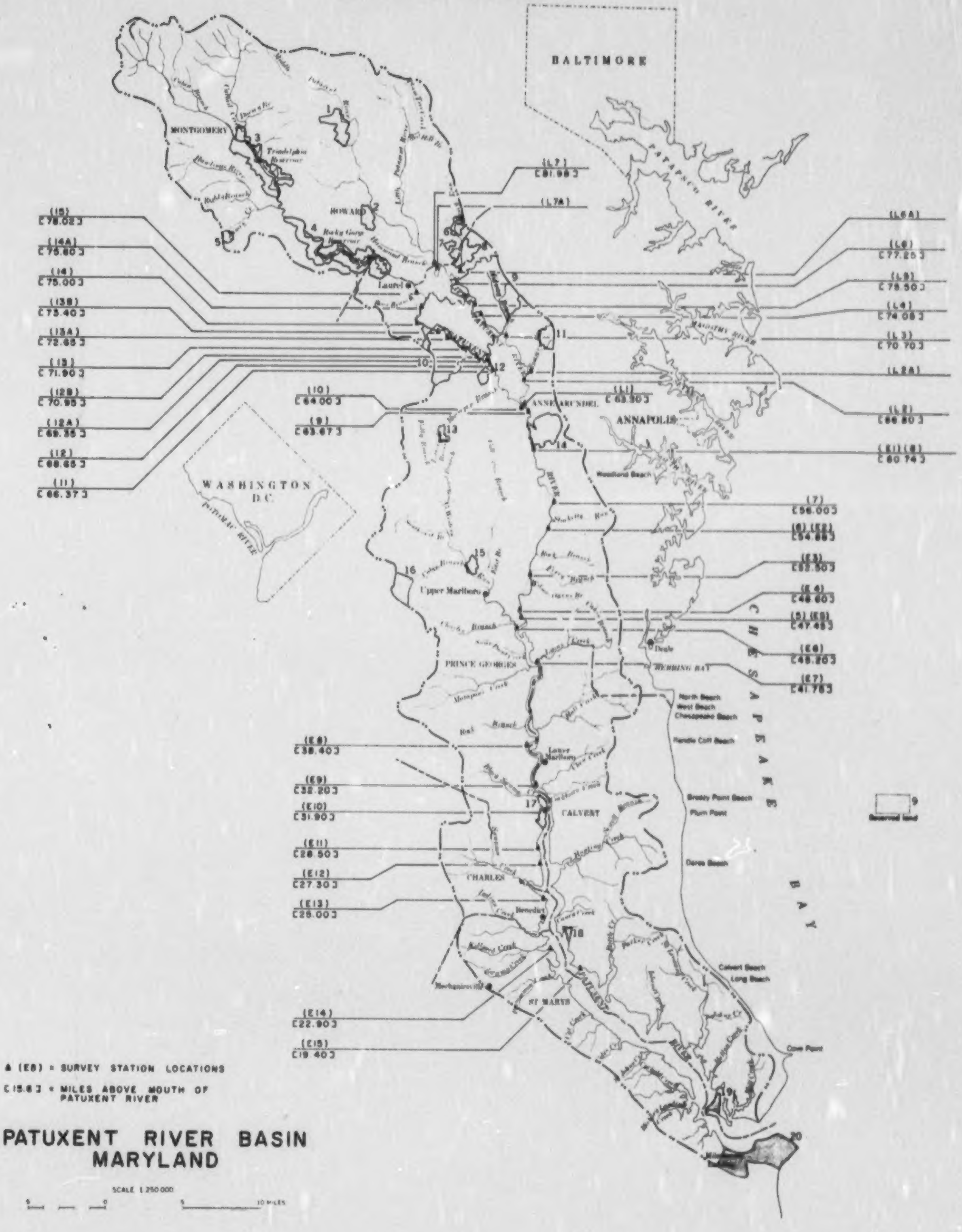
ZONE DESCRIPTION

Zone	Description
I	Main stem of Patuxent River from T.H. Duckett Reservoir to confluence with Little Patuxent River
II	Little Patuxent River from Savage to confluence with main Patuxent River
III	Main stem of the Patuxent River from the confluence with the Little Patuxent River to River Mile 44.0* below the confluence with Western Branch
IV	Patuxent Estuary from River Mile 44.0* to Chesapeake Bay

A schematic diagram of the middle basin, consisting of Zones I, II, and III and for which a mathematical water quality simulation model was developed, is exhibited in Figure A-4.

* River miles are numbered upstream from the mouth.

Reproduced from
best available copy.


BALTIMORE
MONTGOMERY
HOWARD
Triadelphia Reservoir
Rocky Gorge Reservoir
Laurel
PATAPSCO RIVER
MAGOTHY RIVER
SEVERN RIVER
ANNE ARUNDEL
ANNAPOLIS
WASHINGTON D.C.
POTOMAC RIVER
Upper Marlboro
PRINCE GEORGES
CALVERT
CHARLES
Benedict
Mechanicsville
ST MARYS
PATUXENT RIVER
Deale
HERRING BAY
North Beach
West Beach
Chesapeake Beach
Randle Cliff Beach
Breezy Point Beach
Plum Point
Dares Beach
Calvert Beach
Long Beach
Cove Point
CHESAPEAKE BAY
(15) [76.02]
(14A) [75.60]
(14) [75.00]
(13B) [73.40]
(13A) [72.65]
(13) [71.90]
(12B) [70.95]
(12A) [69.35]
(12) [68.65]
(11) [66.37]
(10) [64.00]
(9) [63.67]
(L7) [81.98]
(L7A)
(L1) [63.90]
(L6A)
(L6) [77.25]
(L5) [75.50]
(L4) [74.08]
(L3) [70.70]
(L2A)
(L2) [66.60]
(E1) (8) [60.74]
(7) [56.00]
(6) (E2) [54.86]
(E3) [52.50]
(E4) [48.60]
(5) (E5) [47.45]
(E6) [45.20]
(E7) [41.75]
(E8) [38.40]
(E9) [32.20]
(E10) [31.90]
(E11) [28.50]
(E12) [27.30]
(E13) [25.00]
(E14) [22.90]
(E15) [19.40]
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Reserved land
(E8) = SURVEY STATION LOCATIONS
[15.6] = MILES ABOVE MOUTH OF PATUXENT RIVER
SCALE 1:250,000
5
0
5
10 MILES

PATUXENT RIVER BASIN
MARYLAND

FIGURE IV-1

All of Zone IV and the lower part of Zone III up to river mile 56.0* at New Queens Bridge is considered tidal by the State of Maryland (14) and is thus designated as interstate water. The remaining portion of Zone III and all I and II are non-tidal lying within the State of Maryland and as such are designated as intrastate waters.

B. SOURCES OF POLLUTION

1. Municipal and Industrial Wastewater

There are currently about 60 wastewater discharges in the Basin (Table B-9). Excluding the cooling water discharge of about 720 mgd from the PEPCO**plant, the remaining facilities which discharge wastes serve approximately 110,000 people and discharge about 10 mgd with a BOD before treatment of approximately 17,400 pounds per day. The 1967 operating data for the 15 major facilities, as presented in Table IV-2, show that most of the plants currently have 85 per cent or greater removal of 5-day BOD.

As can also be seen in this table, eight plants, the largest being the Laurel Parkway facility, contribute over 97 per cent of the total sewage load. The remaining loads come from numerous small discharges such as trailer parks. The nutrient loading from all of the waste treatment plants in the Basin was determined to be about 2,500 pounds per day of total Kjeldahl nitrogen as nitrogen.

There are no significant organic industrial waste water discharges in the Basin. The Naval Academy Dairy and the Maryland - Virginia Milk Producers Association, with effluents of less than 0.02 mgd,

---

* River miles are numbered upstream from the mouth.

**PEPCO - Potomac Electric Power Company located at Chalk Point, Maryland

Table IV-2

1967 OPERATING DATA FOR THE MAJOR WASTEWATER TREATMENT PLANTS

Facility	Sewered Population	Flow (mgd)	Influent 1/ BOD (mg/1)	Influent 1/ S.Solids (mg/1)	Effluent 1/ BOD (mg/1)	Effluent 1/ S.Solids (mg/1)	BOD Removal (%)	Effluent 2/ T.Phos. as PO_4 (mg/1)	Effluent 2/ TKN as N (mg/1)	Effluent 2/ NO_2-NO_3 as N (mg/1)
WSSC Water Treatment Plant 3/	-	1.200	-	-	-	-	-	-	-	-
Maryland City	5,000	0.410	210	150	9	60	95	39	7.2	4.5
Laurel Parkway	21,000	2.600	135	180	16	25	88	31	12.2	1.3
Belair-Bowie	23,000	1.900	185	187	20	40	89	45	21.5	1.9
Bowie State Teachers College	500	0.075	65	33	3	1	95	-	-	-
W.R. Grace Co.	-	0.011	153	115	25	30	84	-	-	-
Johns Hopkins Lab	-	0.018	120	87	23	48	81	-	-	-
Savage	1,500	0.113	295	183	5	10	98	22	1.9	10.2
Ft. Meade #2	16,000	1.000	310	260	48	40	84	27	18.3	0.7
Ft. Meade#1	21,000	1.300	210	220	28	32	87	25	14.0	1.3
Md. House of Correction	2,500	0.600	356	248	48	38	86	18	4.0	1.4

Table IV-2 (Continued)

Facility	Sewered Population	Flow (mgd)	Influent 1/ BOD (mg/l)	Influent 1/ S.Solids (mg/l)	Effluent 1/ BOD (mg/l)	Effluent 1/ S.Solids (mg/l)	BOD Removal (%)	Effluent 2/ T.Phos. as PO_4 (mg/l)	Effluent 2/ TKN as N (mg/l)	Effluent 2/ NO_2 - NO_3 as N as N (mg/l) (mg/l)
Patuxent Plant	4,400	0.700	186	394	11	22	94	30	4.4	2.7
Andrews A.F.B.	3,000	0.300	171	734	21	28	87	19	4.5	2.0
Upper Marlboro	700	0.070	225	293	140	100	38	-	-	-
PEPCO Chalk Point Plant 4/	-	720.000	-	-	-	-	-	-	-	-

1/ Analysis by MSDH

2/ Analysis by CFS, FWPCA

3/ Wash water

4/ Cooling water

discharge into tributaries of the Little Patuxent River and have no noticeable effects on the main stem of the Patuxent River. The eight sand and gravel operations located in the basin add to silt loading, especially in the reaches near and below the confluence of the Middle Patuxent and Little Patuxent Rivers. The effects of the silt loading and the cooling water discharges are discussed later in this chapter.

2. Land and Urban Runoff

The study of land runoff was mainly limited to the middle and lower areas, since most of the wastewater discharges occur in these areas. Data reports on the remaining areas have been prepared by Allison (6), (7), (8), (9).

The land runoff or no-point-source pollution in the upper reaches of the main stem have some effect on the water quality in Zone I at Laurel. This effect is minimized by two water supply impoundments on the upper reaches of the Patuxent River. The discharge from T.H. Duckett Reservoir, the lower impoundments, contains about 2.0 mg/1* of BOD and has coliform counts usually less than 1,000 MPN** per 100 milliliters.

Urban runoff from the Laurel area adds about 1.0 mg/l of BOD making the total about 3.0 mg/l. A significant increase in bacteriological pollution with MPN/100 ml counts from 4,000 to 240,000 is the primary effect of urban runoff. Urban runoff at Laurel, as measured at station

---

* mg/l = milligrams per liter

** MPN/100 ml = most probable number per 100 milliliters

15 (Table B-1), including storm drains, WSSC backwash water, and street washings also contains small concentrations of phosphorus and nitrogen (Appendix Tables B-11, B-13, and B-15).

Very low organic pollution loadings are detected in the Patuxent River at Savage as a result of land runoff to the Middle and Little Patuxent Rivers. The quality of water in the Patuxent at Savage is good with BOD's about 2.0 to 3.0 mg/l, DO's near saturation, and low concentrations of nutrients.

During the summer surveys of 1967, conducted by Chesapeake Field Station, it was fairly well established that swampy areas between Laurel and the confluence with the Little Patuxent River were not adding any significant BOD, phosphorus, or nitrogen loading to the system.

Runoff from urban and agricultural areas during the summer months contributed 28 per cent of the BOD loading to the system with a relatively significant amount of nutrients. The BOD loading is typical for an urban-agricultural area.

C. CURRENT WATER QUALITY AND TRENDS

1. Non-tidal Waters

Since 1955, the sewered population of the basin has increased fourfold from 25,000 to the current population of 110,000. The wastewater from the Laurel, Belair, Maryland City, and Patuxent wastewater treatment plants increased twofold from 1963 to 1966. This rapid increase in population has had an adverse affect on water quality in the Patuxent Basin, especially in the middle region of the basin which receives the major portion of the waste discharges.

The effect of an increasing wastewater loading on water quality in the main portion of the Patuxent River Basin is illustrated in Figure IV-2. The years 1955, 1961, and 1966 were chosen for illustrative purposes because the flows and temperatures, the major factors effecting the assimilative capacity of the stream, were very similar in these years. The two large increases in BOD in 1966 were from the Laurel and Belair waste treatment plants and possibly including drainage from the sanitary landfill at Belair. Similar comparisons were made by Allison (18) for the summer surveys of 1964, 1965, and 1966. Although the stream flows varied considerably for each survey, the data indicated two distinct dissolved oxygen depressions in the system; one below the waste treatment plant at Laurel and one below the waste treatment plant at Belair.

Four intensive stream surveys were conducted in 1967 by the Chesapeake Field Station of the FWPCA in conjunction with the MDWR and MDH. A summary of the data from each survey is given in Appendix Tables B-11 through B-18. A detailed discussion and comparison of the 1967 sampling data is given below:

a. Biochemical oxygen demand and dissolved oxygen

The primary source of carbonaceous BOD in the system, as indicated in the previous chapter, is from wastewater discharges. Urban and land runoff is of secondary importance. The BOD loading in Zone I and II is about 1,700 pounds per day. In the main stem of the Patuxent River the loading from the Laurel and Belair plants in 1967 was 330 and 320 pounds per day, respectively. The major loadings in the Little Patuxent were from Fort Meade No. 2, Fort Meade No. 1,

WATER QUALITY COMPARISON

FOR THE LOW FLOW MONTHS OF
JULY, AUGUST and SEPTEMBER
1955, 1961, 1966

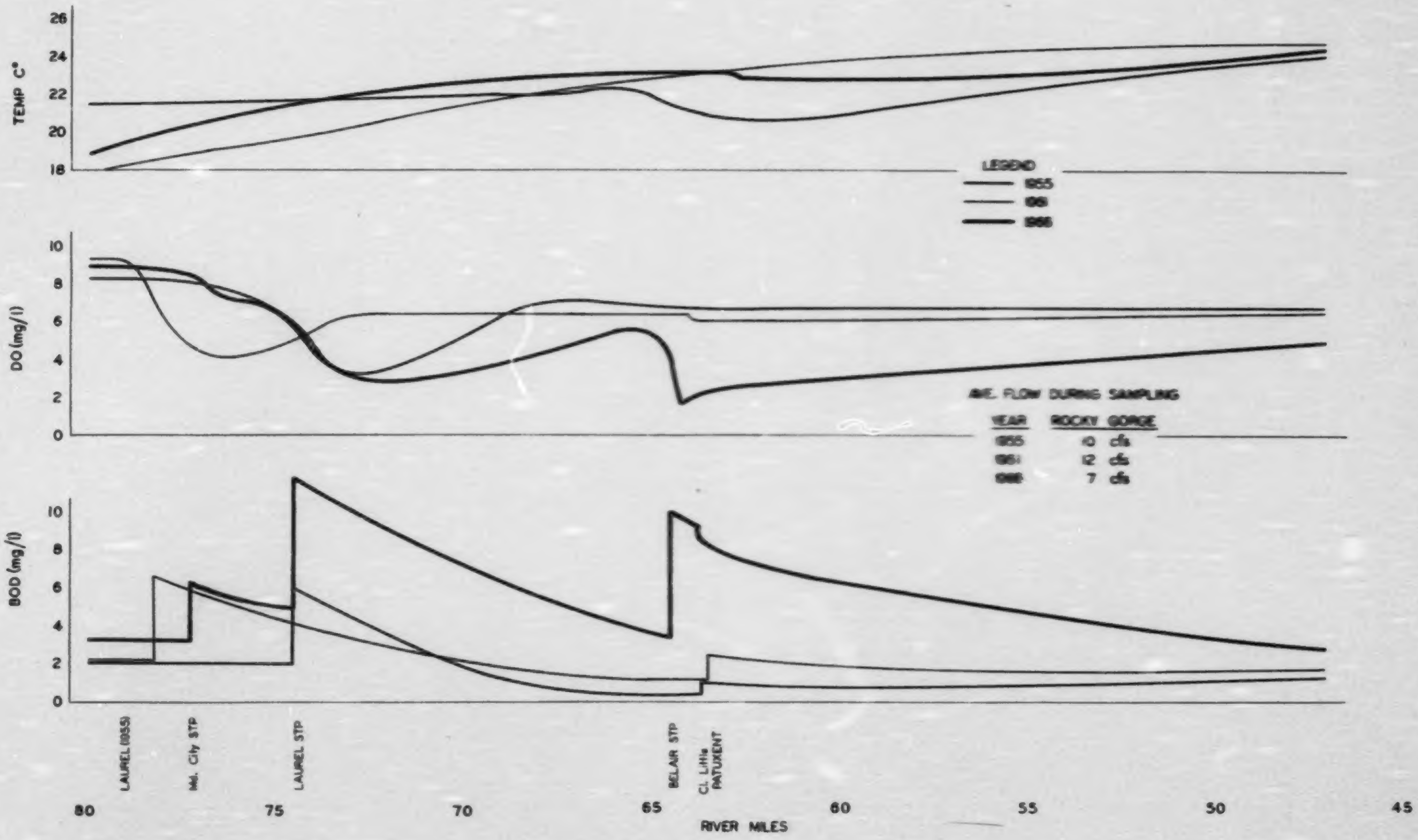


FIGURE IV-2

and the Maryland House of Correction plants with loadings of 370, 270, and 250 pounds per day.

Assuming a BOD of 3.0 mg/l and an average summer monthly flow of 10 cubic feet per second, the combined BOD loading from the T.H. Duckett Reservoir and the Laurel area is about 160 pounds per day. Also assuming a summer flow of 30 cfs* and a BOD of 2.0 mg/l at Savage, the BOD loading from runoff in the Little Patuxent is 320 pounds per day. Runoff from the downstream areas adds an additional 200 pounds per day. The ratio of the BOD contribution from land and urban runoff to BOD in the wastewater is about 1 to 2.5.

The effect of the additional wastewater loadings on the DO in the main Patuxent can be seen in Figure IV-3. The two DO depressions were more prominent during the July-August survey than during the September or October surveys. During the September survey the flow from the T.H. Duckett Reservoir was 39 cfs, a threefold increase from the July-August survey; and in the October survey, corrective actions on the sanitary land fill has been initiated.

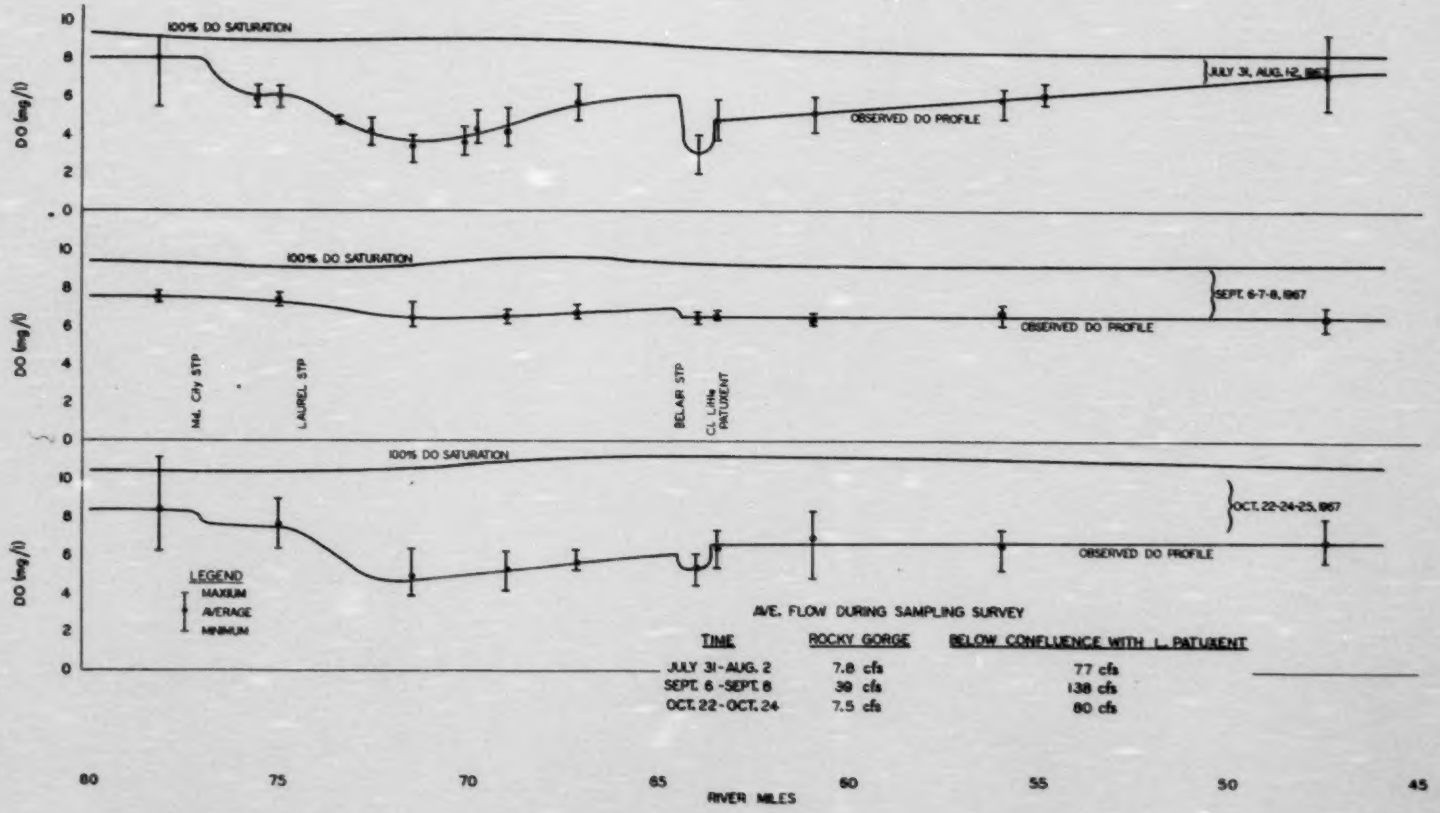
The second DO depression below Belair, which is reduced somewhat by the flow of the Little Patuxent, has a much slower recovery due to the sluggish condition of the river in this reach. As can be seen in Figure IV-4, the DO levels for the summer months in the Patuxent at the John Hanson Highway Bridge are already below 5.0 (15) mg per l. The monthly distribution for May, June, July, August,

---

* cfs = cubic feet per second

OBSERVED D.O. PROFILES

PATUXENT RIVER BASIN
DURING INTENSIVE SAMPLING SURVEYS
1967



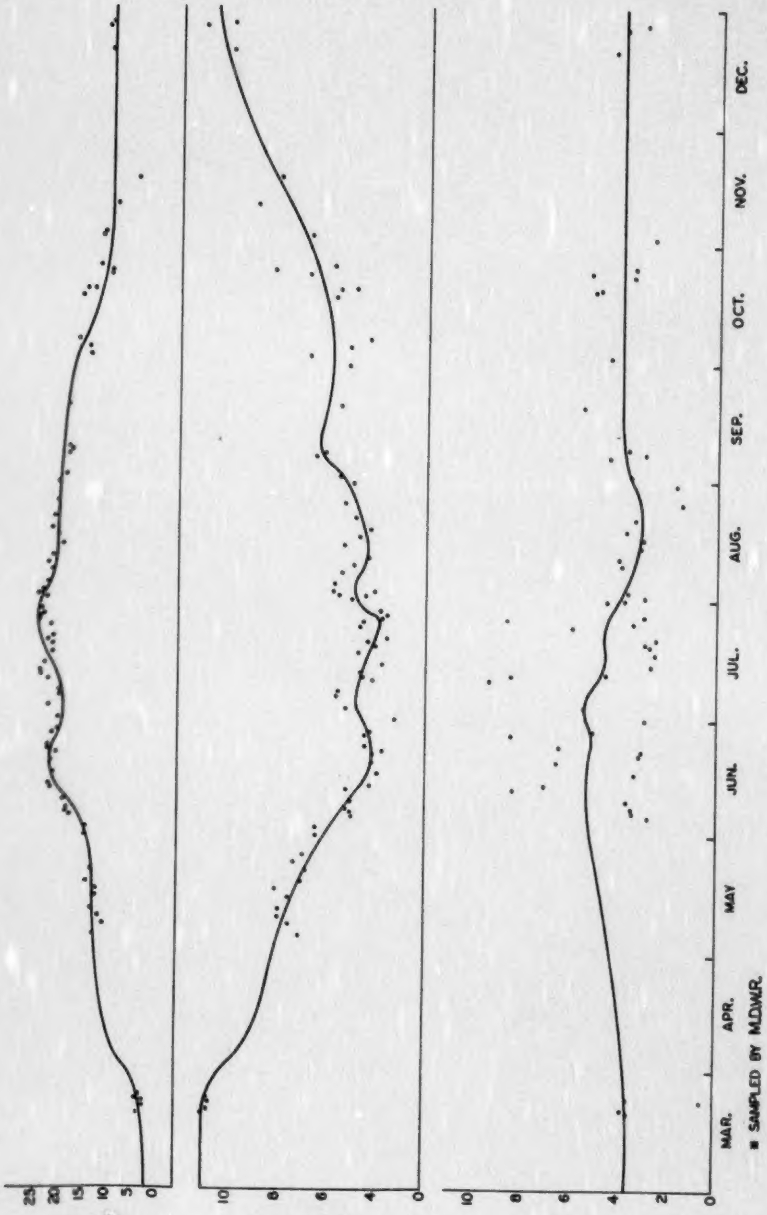
AVE. FLOW DURING SAMPLING SURVEY

TIME	ROCKY GORGE	BELOW CONFLUENCE WITH L. PATUXENT
JULY 31-AUG. 2	7.8 cfs	77 cfs
SEPT. 6 -SEPT. 8	39 cfs	138 cfs
OCT. 22-OCT. 24	7.5 cfs	80 cfs

FIGURE IV-3

OBSERVED TEMPERATURE, DO and BOD DATA *

PATUXENT RIVER BASIN
JOHN HANSON HIGHWAY BRIDGE
1967



* SAMPLED BY M.D.W.R.

FIGURE IV-4

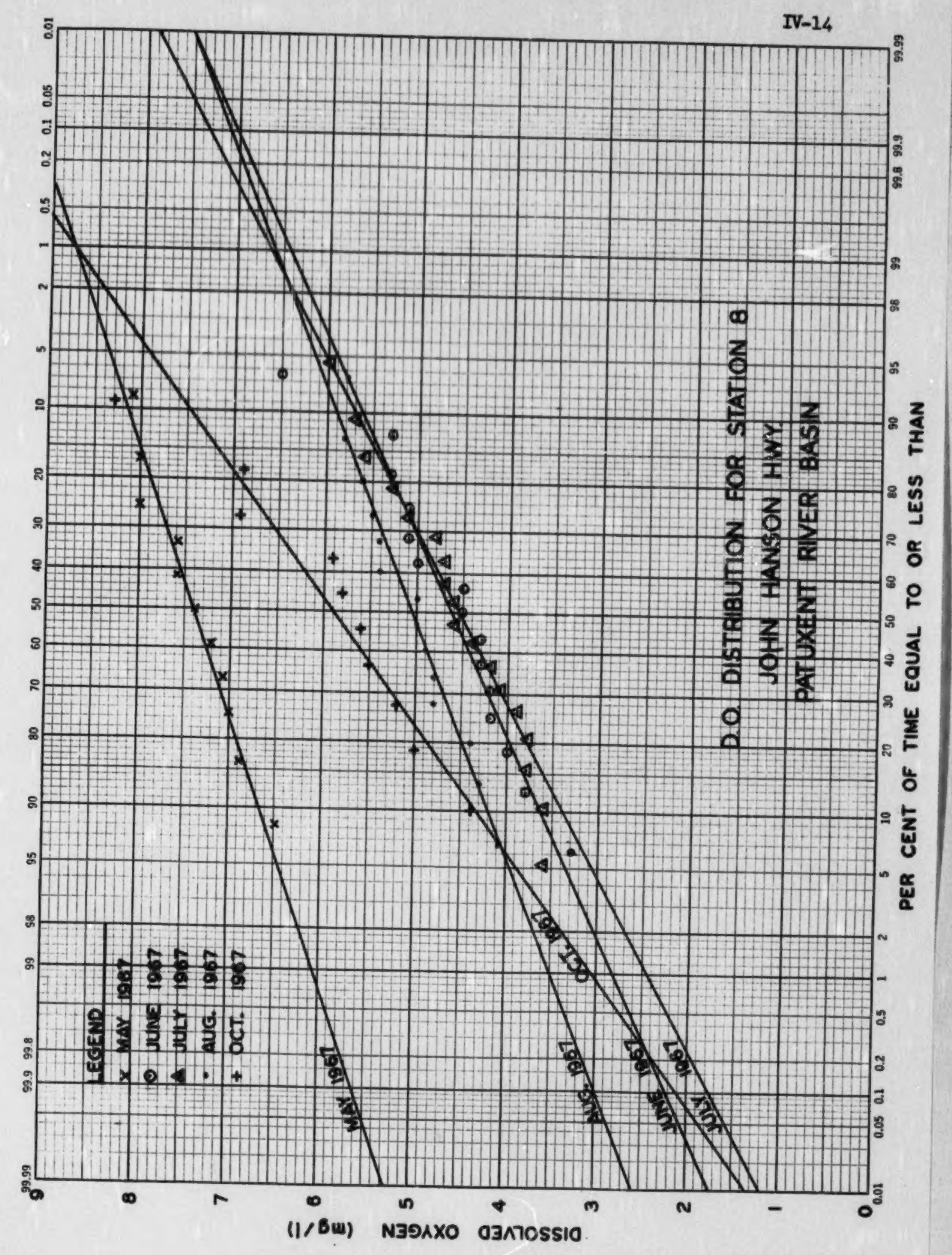
and October of 1967 indicated mean monthly DO values of 7.4, 4.6, 4.5, 5.0, and 5.8 mg/l (Figure IV-5).

The DO in the Little Patuxent above the wastewater discharges of Fort Meade was, on the average, greater than 6.5 mg/l in the summer months of 1967 (Figure IV-6). In the sections below the discharges, the average DO in the summer months was about 5.5 mg/l. Similar DO concentrations were observed during the 1967 summer survey of the Chesapeake Field Station (CFS) as summarized in Tables B-11 through B-18.

To determine the amount of BOD being contributed from the swampy area below the confluence of the Patuxent and Little Patuxent Rivers an intensive survey was conducted in September of 1967. The survey showed no significant amount of BOD being contributed from the swampy area. However, as shown in Figure IV-7, data from the survey indicated: (1) that most of the total phosphorus and total Kjeldahl nitrogen was coming from the wastewater effluent; (2) that the sanitary landfill below Belair was contributing about 600 pounds of BOD per day; (3) that very little BOD was coming from the land runoff between Laurel and Belair; and (4) that the highly chlorinated effluents were causing a growth lag in the BOD analysis.

At stations immediately below the effluents, the BOD* values, which were not corrected for chlorination effects, were less than at stations above the discharges.

* As shown in Figure IV-7, the interpreted BOD values were used in model verification since the phosphorus and TKN parameters and subsequent sampling indicated that BOD determinations of grab samples were greatly affected by chlorination.

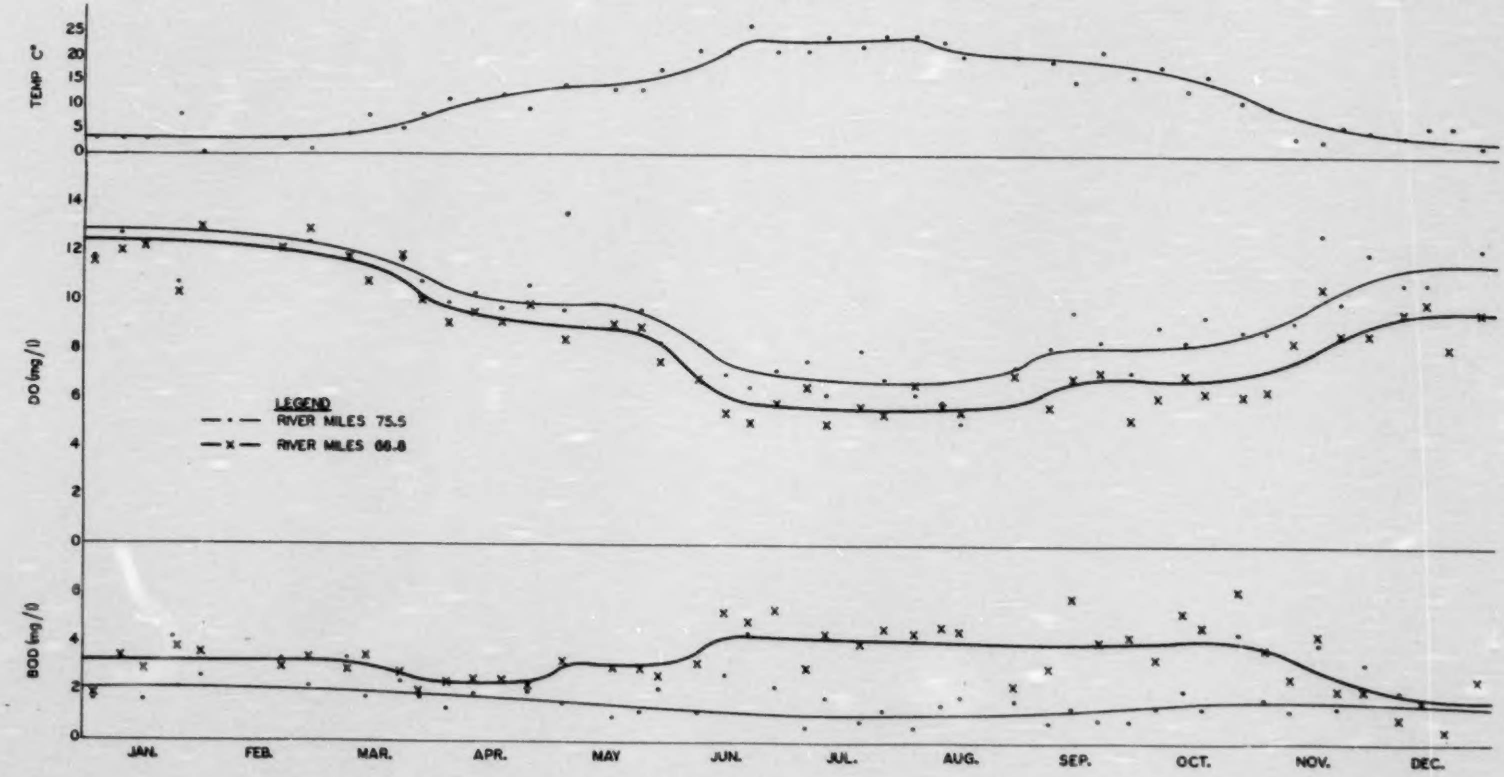


D.O. DISTRIBUTION FOR STATION 8
JOHN HANSON HWY.
PATUXENT RIVER BASIN

FIGURE IV-5

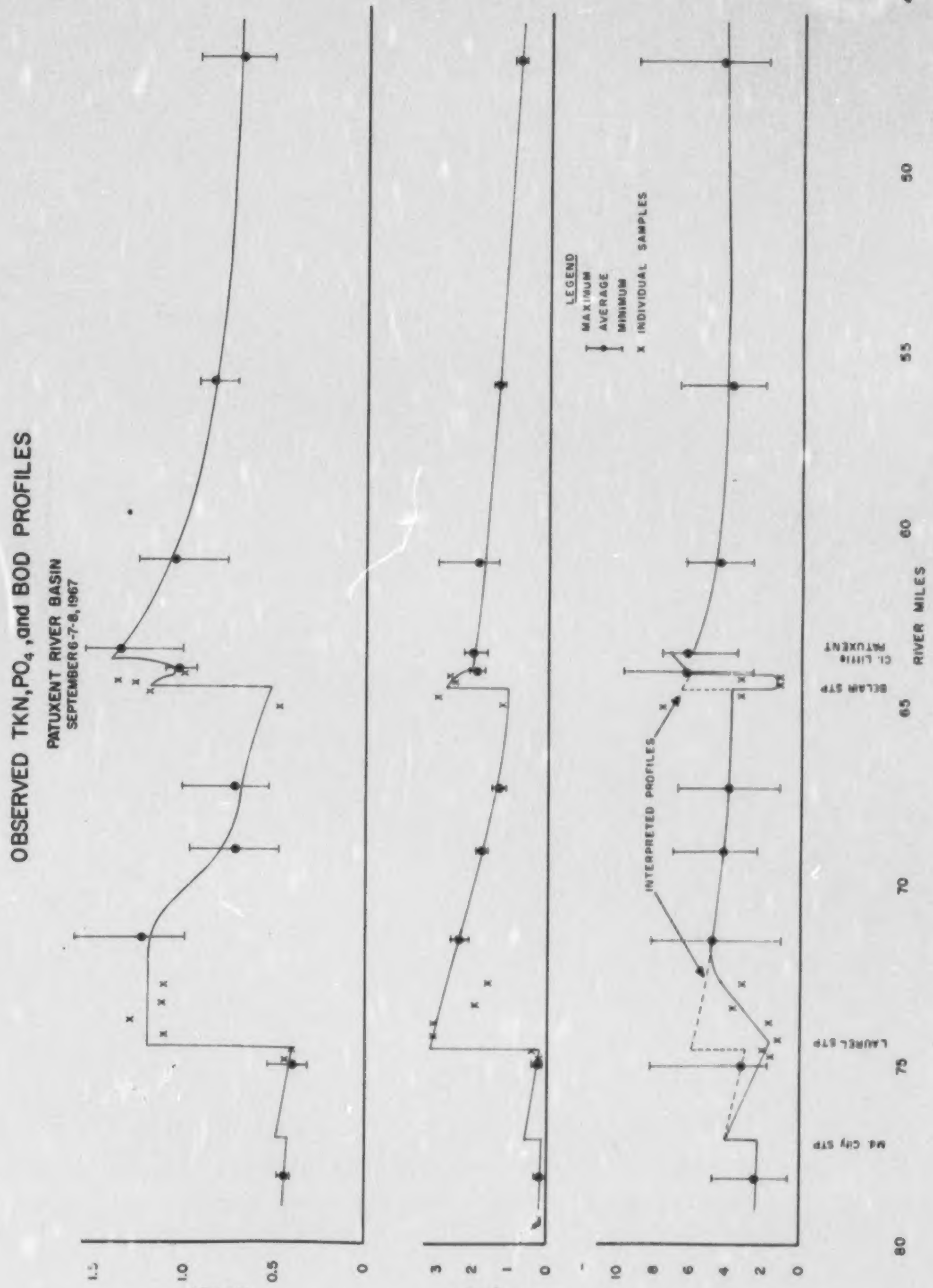
OBSERVED TEMPERATURE, DO and BOD DATA *

LITTLE PATUXENT RIVER BASIN
ROUTE 195 RIVER MILE 75.5 - ROUTE 429 RIVER MILE 66.8
1967



* SAMPLED BY FORT G.G. MEADE

FIGURE IV-6



OBSERVED TKN, PO_4, and BOD PROFILES

PATUXENT RIVER BASIN

SEPTEMBER 6-7-8, 1967

FIGURE IV-7

Similar effects of chlorinated wastewater effluent samples, not corrected for chlorination, were observed during this survey.

b. Nutrients and nitrogenous oxygen demand

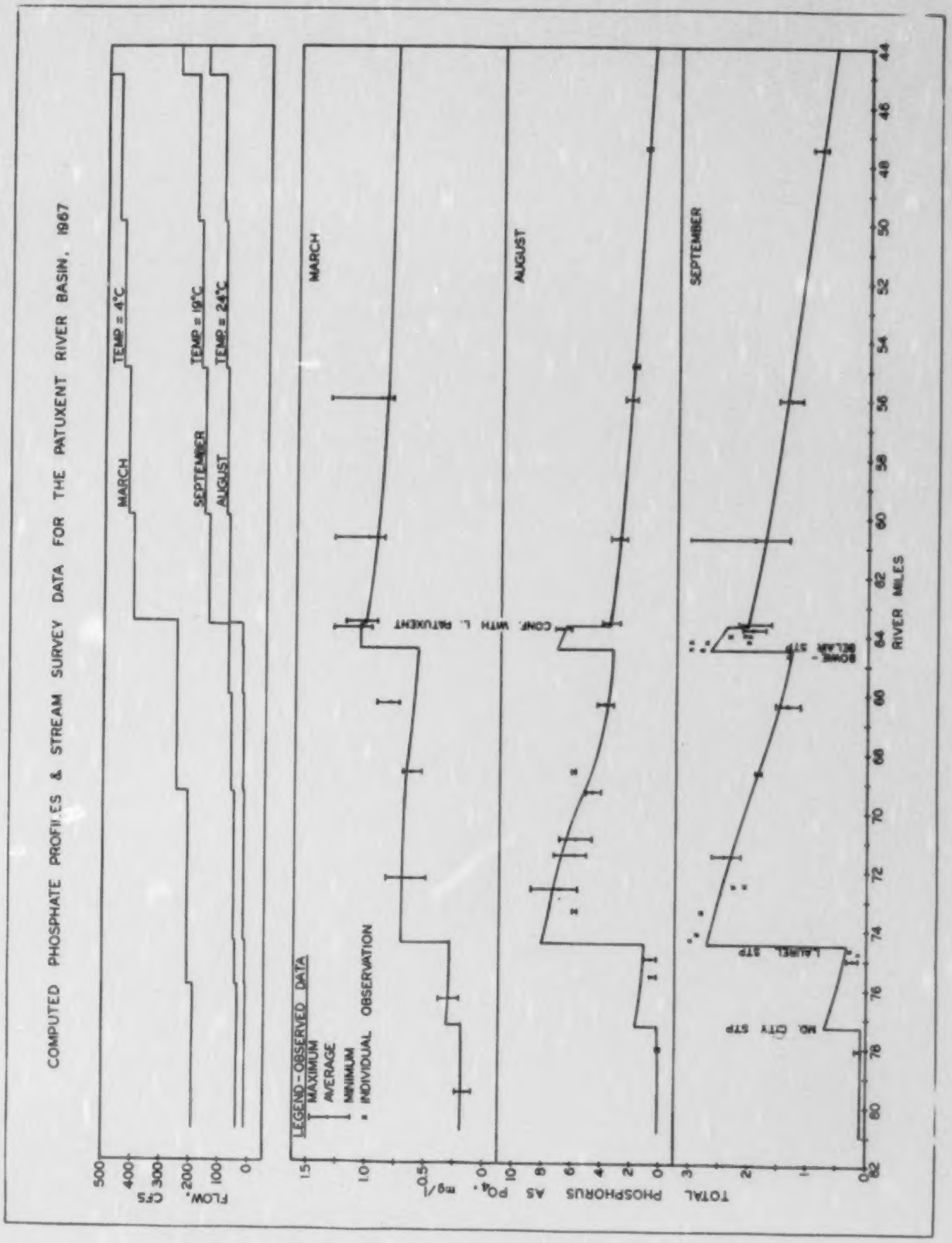
About 2,500 pounds per day of phosphorus is discharged into the middle reaches of the Patuxent Basin as a component of the wastewater effluents. The contribution from urban and land runoff during the summer months at Laurel, Savage, and downstream areas is about 6, 15, and 10 pounds per day respectively.

The total nitrogen loading in the wastewater effluents is about 1,350 pounds per day. The load contribution at Laurel, Savage, and downstream areas during the summer months is about 110, 120, and 80 pounds per day.

It appears from nutrient data obtained in 1967 that over 99 per cent of the phosphorus and 85 per cent of the total nitrogen contributions are from the wastewater effluents with the remainder from land and urban runoff.

The large increase of TKN and $NO_2 + NO_3$ observed during the August 1967 survey was also attributed to treated wastewater effluents. The concentration of phosphorus decreases (Figure IV-7 and IV-8) downstream from the points of discharge as a result of the utilization of phosphorus or its absorption by sediments in the stream bed. The loss of phosphorus to aquatic vegetation or sediments has been expressed mathematically and a model capable of predicting phosphorus concentration has been developed, (11).

TKN concentrations in the portion of the river between Laurel Parkway and Bowie-Belair waste treatment plants decreased considerably



COMPUTED PHOSPHATE PROFILES & STREAM SURVEY DATA FOR THE PATUXENT RIVER BASIN, 1967

FIGURE IV-8

followed by a simultaneous increase in NO_2+NO_3 nitrogen (Figure IV-9). The natural oxidative process of converting TKN nitrogen to NO_2+NO_3 nitrogen results in a nitrogenous oxygen demand.

In 1968, MDWR (20) in a cooperative study with FWPCA demonstrated that the oxidation of NH_3 to NO_3 is a major factor in the DO balance in this reach. This can be readily seen in Figure IV-10 in that the DO depression below River mile 72 results mainly from the nitrogenous and not from the carbonaceous demand as measured by the total carbon (TOC). Similar observations have been made in studies on the highly nutrient loaded Potomac (12) and Thames Estuaries (13).

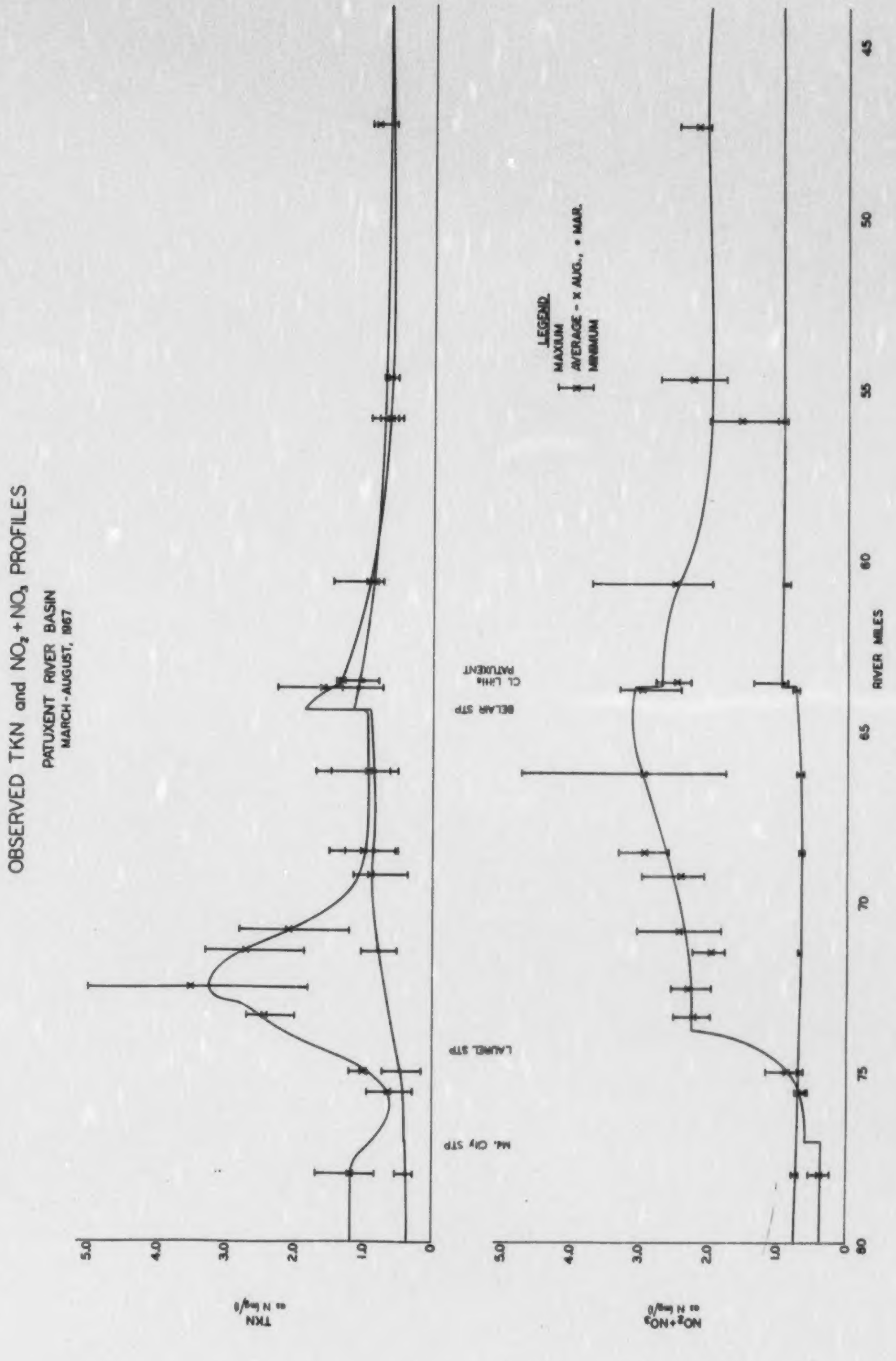
c. Bacterial indicators

The four reaches with high bacterial pollution are (1) the main stem of the Patuxent River below Laurel, (2) Dorsey Run below the Maryland House of Correction, (3) Towser Run below the Naval Academy Dairy and (4) the main stem of the Patuxent River near Wayson's Corner. In these areas coliform counts of over 10,000 and E. coli* counts of over 300 MPN/100 ml were observed during July and August. Extremely high counts of E. coli (over 9,000) were detected below Laurel and counts of over 80,000 E. coli in the Little Patuxent below Dorsey Run. High E. coli counts (over 60,000) were also observed in Towser Branch below the Naval Academy Dairy in the October survey of 1967.

d. Biological indicators

A biological survey of the upper and middle Patuxent River Basin was made by the FWPCA in 1967 (14). The purpose of the survey

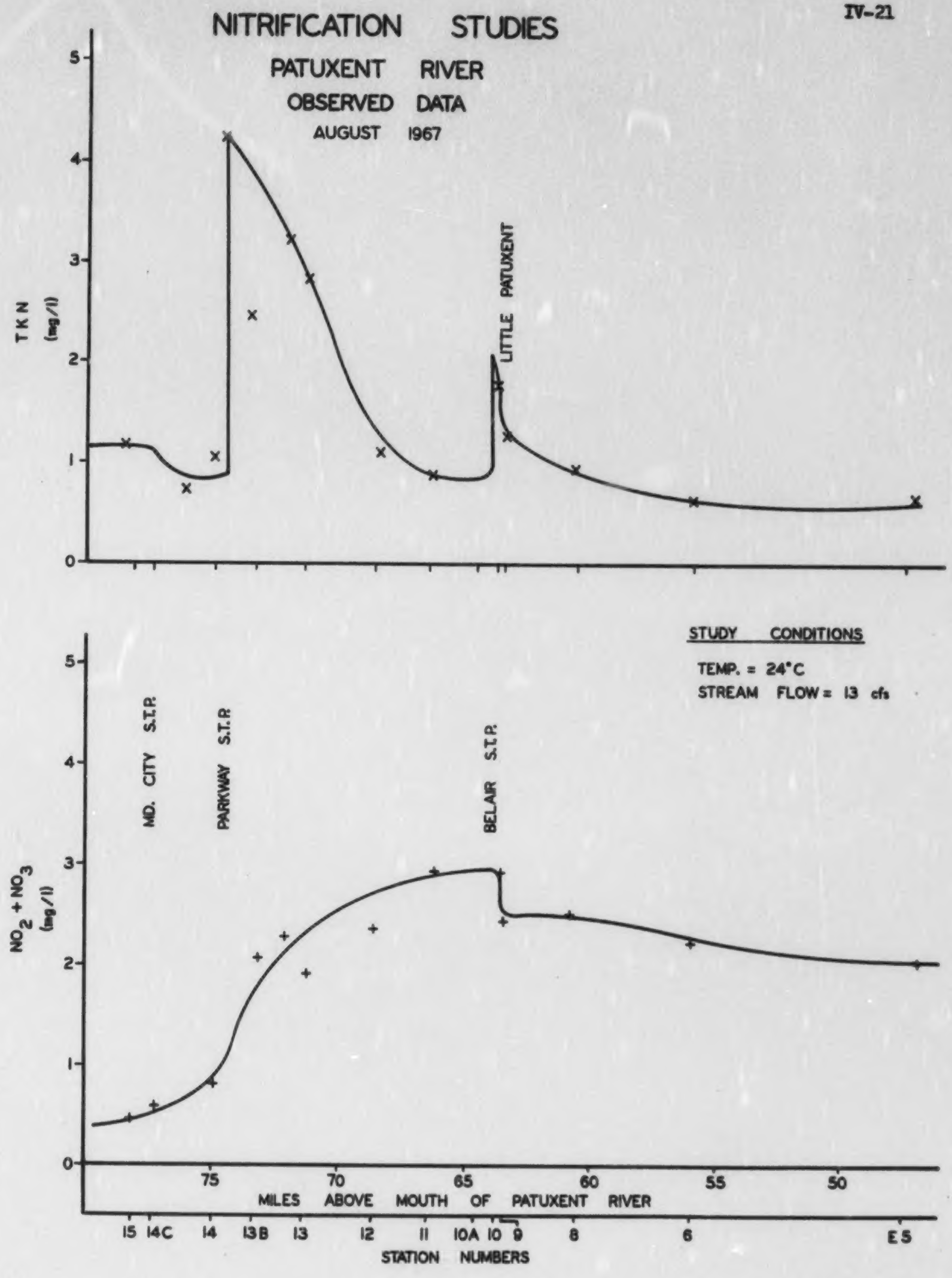
* Maryland state standards for the Patuxent River and tributaries limit the fecal coliform (E. coli) counts to a maximum of 240 MPN/100 ml.



OBSERVED TKN and $NO_2 + NO_3$ PROFILES

PATUXENT RIVER BASIN
MARCH - AUGUST, 1967

FIGURE IV-9



NITRIFICATION STUDIES
PATUXENT RIVER
OBSERVED DATA
AUGUST 1967

FIGURE IV-10

was to supplement existing chemical and bacteriological data on the upper and middle basin. Benthic organisms were sampled at 35 stations in the study area.

2. Tidal Waters

The estuarine portion of the Patuxent River varies in width from less than 200 feet near Wayson's Corner to over 2 miles at its confluence with the Chesapeake Bay. The average water depth varies from 10 feet at Wayson's Corner and 37 feet at Benedict Bridge to 120 feet at Solomons. The average tidal ranges for Nottingham, Benedict Bridge, and Solomons are 2.5, 1.9, and 1.2 feet respectively.

The water quality and ecology of the Patuxent Estuary have been extensively studied by the Chesapeake Biological Laboratory (CBL) of the Natural Resources Institute of the University of Maryland since the late 1930's. During the past decade various cooperative studies by the USGS, CBL, MDWR, FWPCA, and other agencies have been conducted in the Patuxent Estuary. Recent activities in the estuary were initiated primarily to determine the effect of thermal discharges from the PEPCO plant on the water quality and ecology of the estuaries.

Appendix Tables B-4 through B-9, B-11, B-12, and B-14 through B-19 summarize all surveys, studies, and research activities related to water quality in the Patuxent River Basin.

a. BOD and DO concentrations

There was only a small difference in dissolved oxygen concentrations for a given sampling course at the various mile points throughout the middle and lower parts of the estuary. No significant trends toward increased or decreased dissolved oxygen levels are evident for the period from 1962 to 1967. The dissolved oxygen concentrations in the estuary at Lower Marlboro vary from about 6.0 mg/l in the summer to about 12 mg/l in the winter (Figures IV-11 and IV-12).

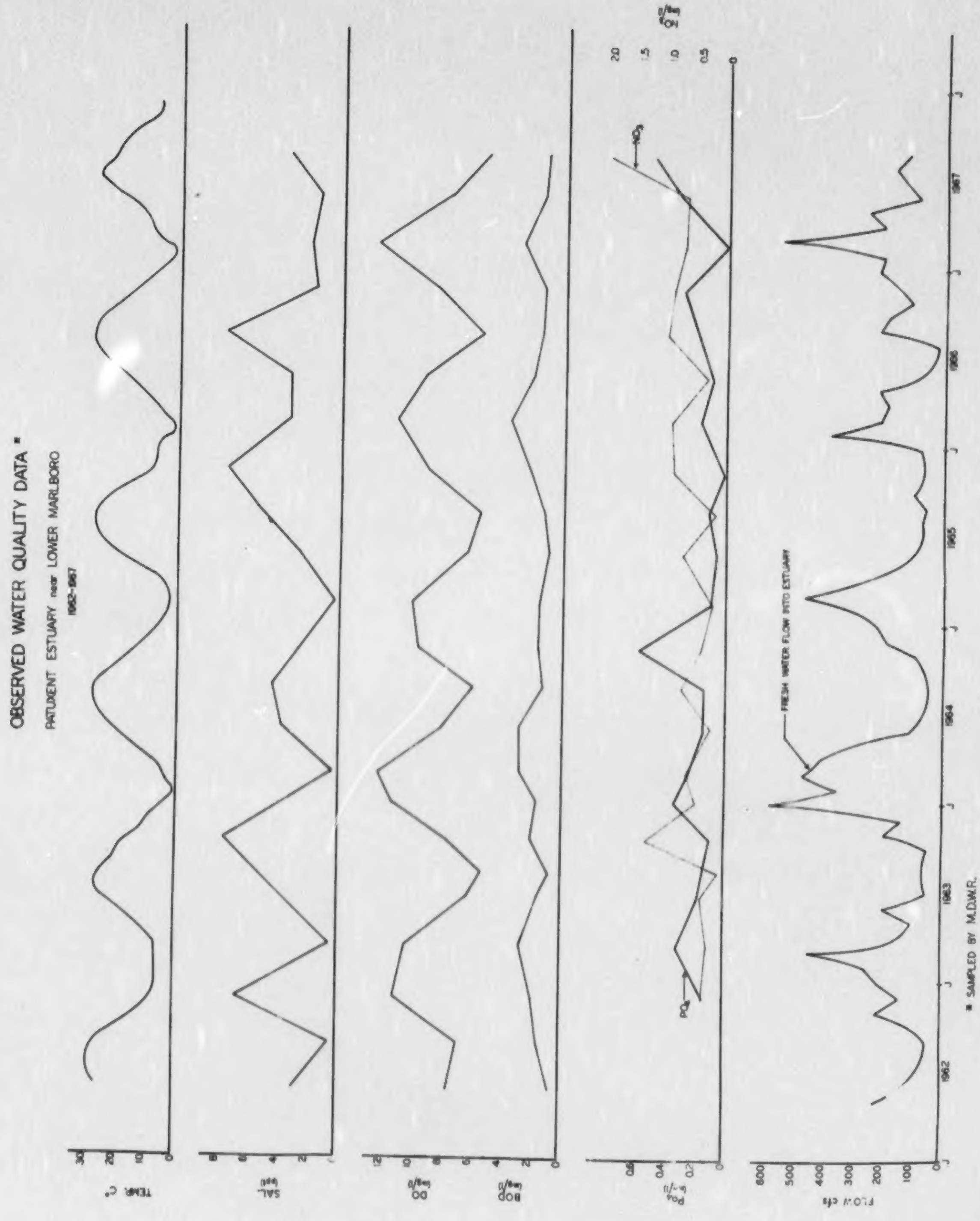
The annual distribution of BOD in the estuary at Lower Marlboro varies from 1.0 to 4.0 mg/l with the higher concentrations occurring during winter and spring flows. The BOD of the upper estuary near Wayson's Corner varies from about 2.0 to 6.0 mg/l.

In the upper part of the estuary below Wayson's Corner dissolved oxygen levels below 4.0 mg/l have been observed during the summer months of 1968 and 1969. Water quality in this area is often below the DO standard of 5.0 mg/l. The Western Branch Sewage Treatment Plant of WSSC which is under construction will be discharging into this reach.

b. Nutrients and Chlorophyll

In the past four years the amount of nutrients (phosphorus and nitrogen) being discharged into the Patuxent River system has increased more than twofold in the non-tidal portion of the Basin. This increased loading to the system has been reflected in increased concentrations of nitrates in the estuary (Figure IV-13). The concentrations of phosphate as PO_4 at the various sampling stations in the estuary indicates a twofold increase in phosphorus as P for the month of August from 1964 to 1967. The 1967 levels of phosphorus in the estuary varied from about 0.5 mg/l in the upper portions of the estuary to about 0.25 mg/l in the lower portions.

A similar trend of increasing nitrates can be seen for August in the same figure. The organic nitrogen, while exhibiting a base



OBSERVED WATER QUALITY DATA *

PATUXENT ESTUARY near LOWER MARLBORO

1962-1967

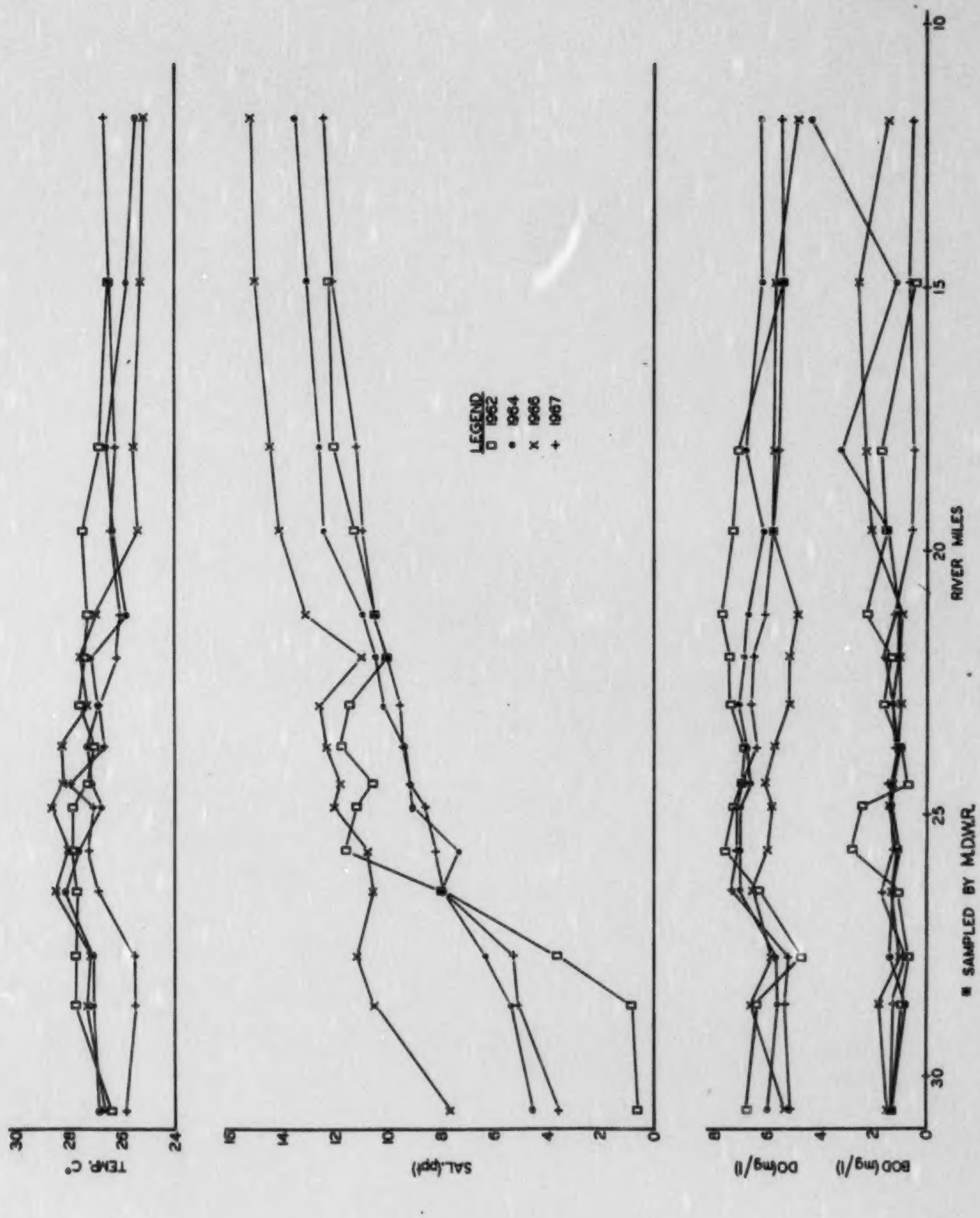
* SAMPLED BY M.D.W.R.

FIGURE IV-11

OBSERVED WATER QUALITY DATA *

PATUXENT ESTUARY

AUGUST - 1962, 1964, 1966, 1967



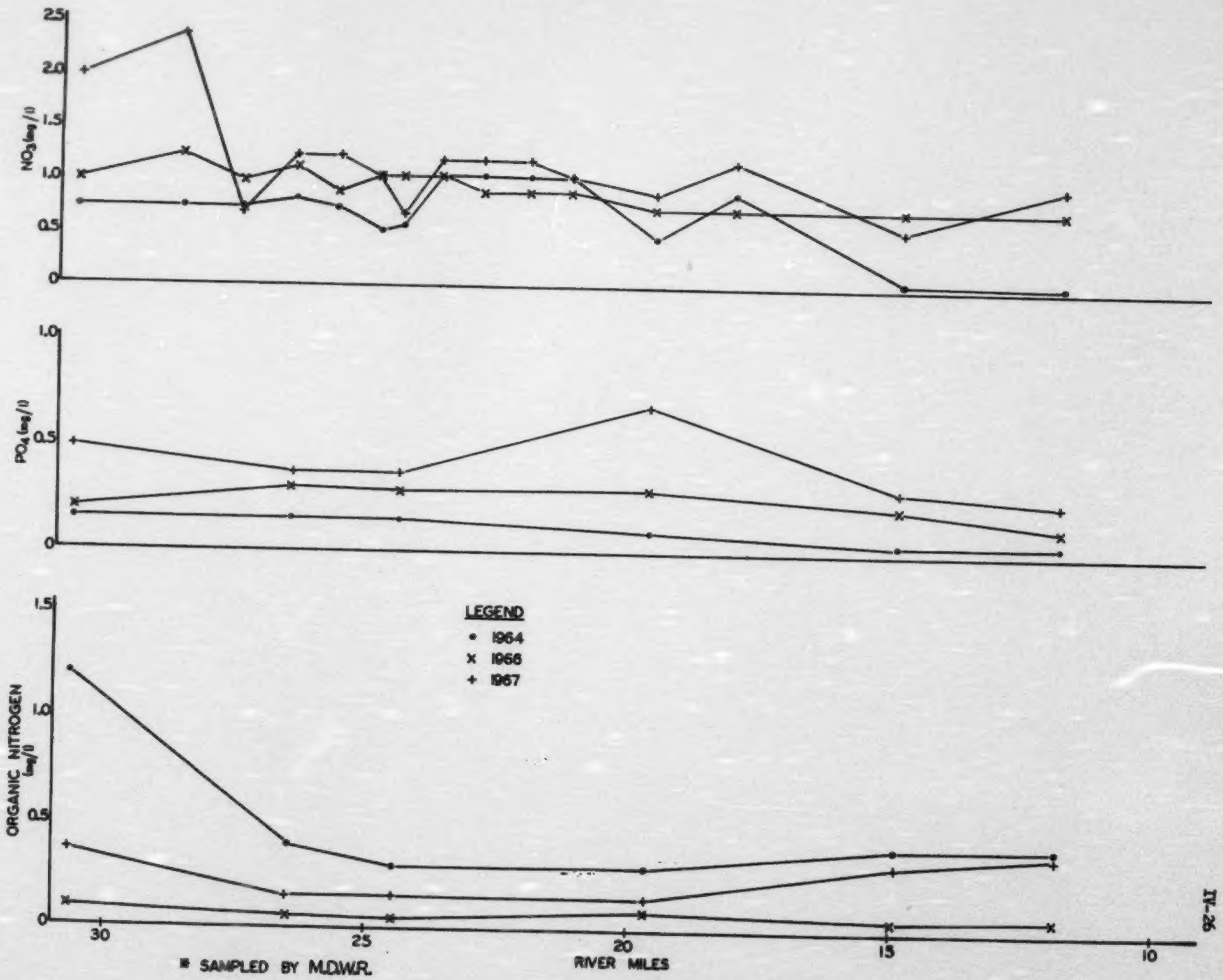
* SAMPLED BY M.D.W.R.

FIGURE IV-12

OBSERVED WATER QUALITY DATA *

PATUXENT ESTUARY

AUGUST – 1964, 1966, 1967



* SAMPLED BY M.D.W.R.

FIGURE IV-13

concentration in the lower portion of the estuary, does not follow the trend increasing nitrate and phosphorus concentrations.

Mihursky et.al. (15, 19 and 20) has studied various biochemical, physical, and ecological aspects of the lower estuary. Although no known nuisance algae problems presently exist in the lower estuary the standing crop of algae, as measured by chlorophyll extraction, is greater in the upper portion of the lower estuary where the nutrient levels are the highest (Figure IV-14). Although the chlorophyll data from 1966 to 1967 have not been completely analyzed, they indicate that the standing crop is larger than in the period from 1963 to 1966, reflecting an increase in nutrient loading to the estuary.

The nutrient-algae relationships in the upper and middle portions of the Patuxent Estuary are currently being studied by the Chesapeake Technical Support Laboratory of the FWPCA. The algal population in the reach from River Mile 31 to 44 had chlorophyll concentrations of over 50 ug/l in May 1968 (Figure IV-15). A peak of the bloom, with a concentration in May 1968 of 180 ug/l, occurred near River Mile 42, a shallow and fairly wide portion of the Estuary commonly referred to as Jug Bay. In July 1968, chlorophyll levels of 300 ug/l were observed near Truman Point in the middle estuary. These levels are approaching conditions in the Potomac Estuary which usually occur in mid and late summer.

The nutrient level below Western Branch at River Mile 45.2 begins to decrease rapidly in the shallow water of Jug Bay. When the Western

PATUXENT RIVER ESTUARY
CHLOROPHYLL and TURBIDITY

NATURAL RESOURCES INSTITUTE- U. OF MD.

1963 TO 1965

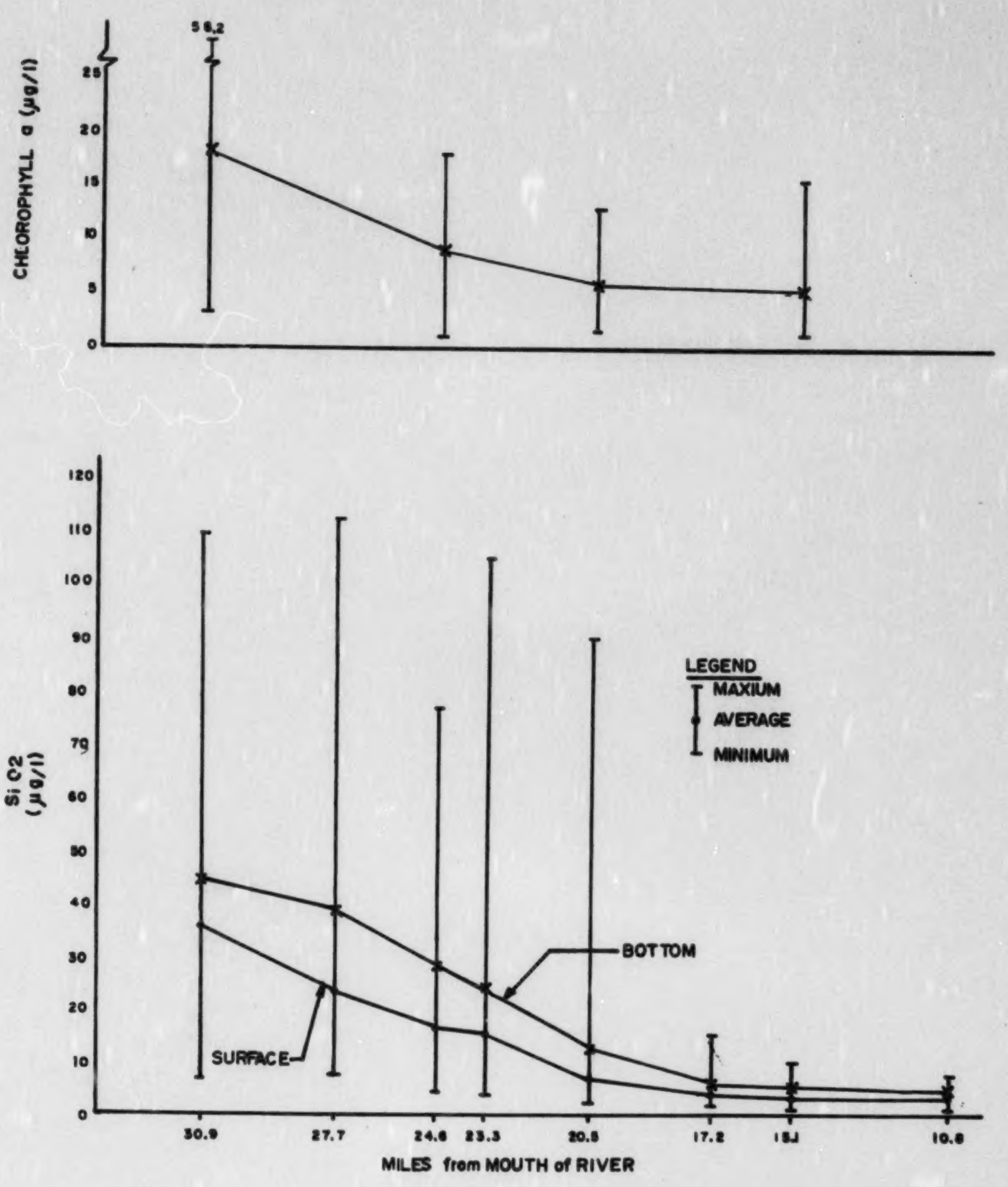


FIGURE IV-14

PATUXENT ESTUARY NUTRIENT SURVEY

MAY 5, 1968

Chesapeake Field Station

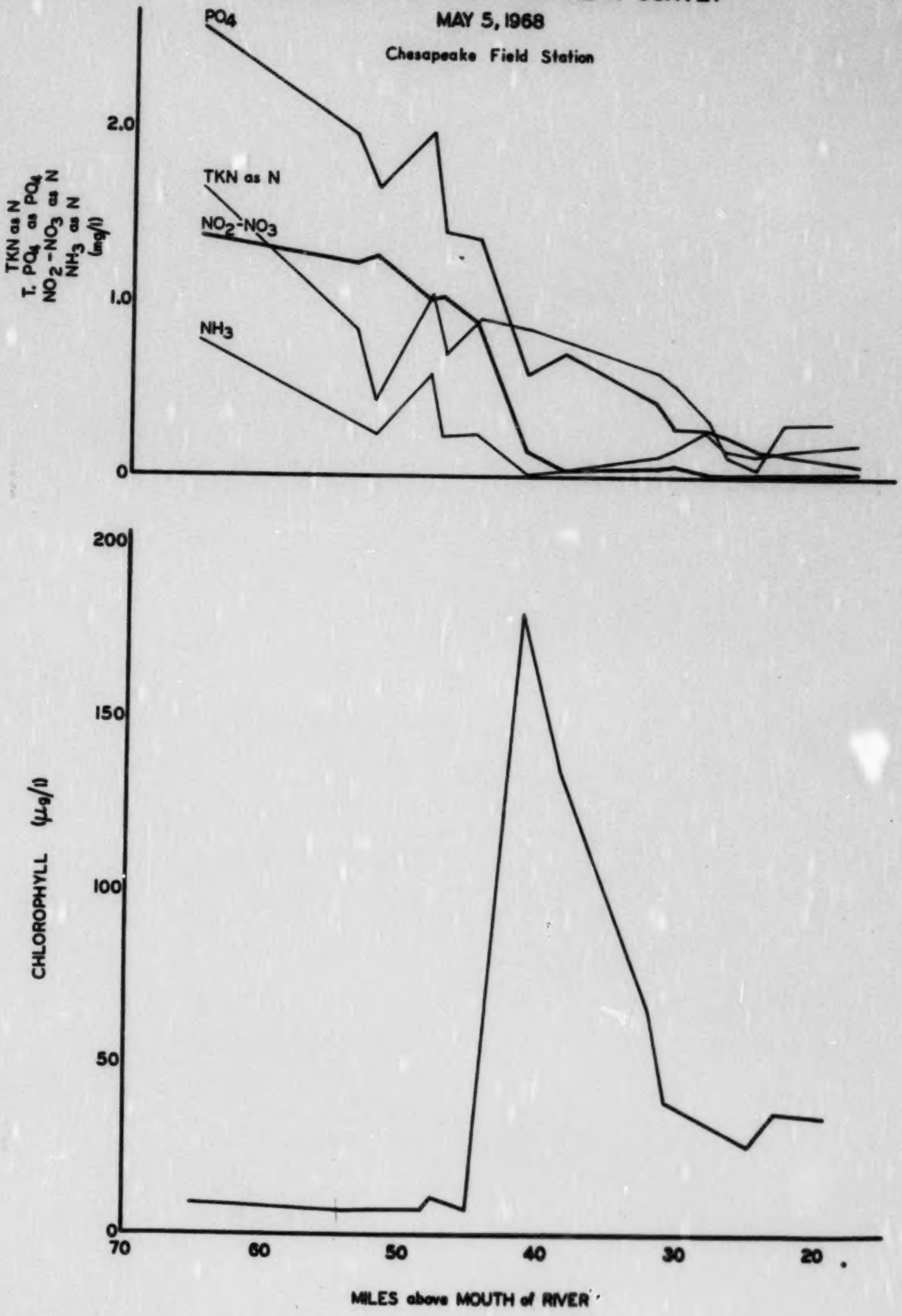


FIGURE IV-15

Branch wastewater treatment plants are put into operation, the nutrient level in the area of Jug Bay will be increased significantly and may result in excessive algal growths as far down the Estuary as Benedict.

c. Salinity

The lower portion of the Estuary is a two-layer system with a net upstream movement of subsurface, high salinity, and high density water. The less dense fresh water has net downstream movement per tidal cycle. The salinity (Figure IV-12) for August of 1962, 1964, and 1966 was much higher than for August of 1967. The August 1967 flow was fivefold greater than the August flow of 1966. In comparing the salinity profiles prepared by Nash (23), before 40 to 50 mgd were diverted from upstream reservoirs to Washington, D.C., with the current profiles prepared by Mihursky (24), it appears that the salt wedge has moved upstream about 10 to 15 miles.

d. Suspended materials

Approximately 183,000 tons of sediment are deposited in the estuary each year (17). Turbidity measurements by Mihursky (24), (Figure IV-14) show relatively high values in the upper portion of the river with gradually decreasing levels in lower portions. Data obtained by Allison (7) support that developed by Mihursky. Allison obtained turbidity values of from 30 to 50 mg/l during the month of August at Lower Marlboro and less than 5 mg/l in the Lower estuary. Nash (23) reports that the lower estuary below Benedict is relatively free of suspended matter and turbidity.

e. Bacterial indicators

The coliform counts at Lower Marlboro range from about 1,000 to 4,000 MPN/100 ml in the lower 20 miles of the estuary. The *E. coli* level follows the same pattern as the coliform count with levels usually less than 100 in the upper estuary to levels less than 5 in the lower 20 miles of the estuary.

f. Temperature

Water temperature in the estuary varies principally with the tidal cycle, time of day, season of the year, and annually. Nash (23) postulated that the seasonal temperature changes are initiated sooner upstream as a result of increasing surface-volume ratios.

The reverse pattern was observed during 1967 in the non-tidal portion of the Basin. Water temperature increased downstream during the summer months and decreased during the winter months near Wayson's Corner. It appears that the upstream waters are affected more than downstream waters by air temperature, which is 3 degrees Fahrenheit warmer at Solomons than at Laurel, and by ground water flow.

Temperatures during the month of August in the upper portion of the estuary are about 1 to 2 degrees F. higher than in the lower estuary (Figure IV-12). The mean water temperatures at Lower Marlboro during the months of July and August of 1966 were 83.0 and 80.0 degrees F., with a standard deviation of 6.0 degrees F. The mean July and August 1966 air temperatures for Prince Frederick, about 8 miles away, were 77.0 and 76.0, with a standard deviation of 5.0 degrees F.

The monthly averages and extremes of surface water temperatures at Solomons as determined by Beavin (25) for a 20-year period are given in Table B-20.

CHAPTER V

FRAMEWORK FOR ANALYSIS

As indicated in the previous chapter, the wastewater loading to the Patuxent River is projected to increase fourfold by the year 1980. Furthermore, as established in Chapter VII, the water quality in the main stem of the Patuxent as measured by the DO has in some reaches fallen below the standards adopted by the State of Maryland. Associated with the low DO problem in the non-tidal portion of the basin is the increasing nutrient loading to the estuary.

A pollution abatement program for the Patuxent River Basin must take into consideration the physical, institutional and legal arrangements that exist in the Basin. The effect of these factors on the planning process is discussed in the following paragraphs.

A. WATER QUALITY STANDARDS AND IMPLEMENTATION PLAN

In 1967, the State of Maryland (29)

> " . . . in order to provide for the enhancement of the water quality where such quality has deteriorated or is deteriorating, for the conservation of water quality where such quality is good or satisfactory, and for the protection of lawful and reasonable uses . . . "

established water quality standards for both inter- and intrastate waters. A plan for implementation and enforcement of the water quality standards for all of Maryland's waters was also established. The standards and the implementation plan were approved and adopted by the U.S. Department of the Interior in August 1967. Any pollution abatement plan developed for the Basin must consider the existing approved standards or suggest modifications to the standards where the modification would result in improved water quality.

1. Water Uses

The uses of waters of the Patuxent River, including the estuary, were grouped into six categories as follows (29):

I. Shellfish harvesting
II. Public or municipal water supply
III. Water contact recreation
IV. Propagation of fish and other aquatic life and wildlife
V. Agricultural water supply
VI. Industrial water supply

For each of the water use categories: bacteriological, dissolved oxygen, pH, and temperature standards, were specified. The designated water uses of applicable water zones of the Patuxent River are presented in Table V-1.

2. Water Quality Standards

The parameter most indicative of water quality in a free flowing stream or estuary is dissolved oxygen (DO). Hence, wastewater treatment requirements and/or flow regulation needs were determined using a mean monthly dissolved oxygen level of 5.0 mg/l with a minimum level of 4.0 mg/l. This is the approved standard for the waters of the Patuxent River in the study area.

3. State Implementation Plan

The primary responsibility for water quality control and pollution abatement is shared by two Maryland state agencies, the Maryland Depart-

Table V-1

DESIGNATED WATER USES FOR VARIOUS WATER ZONES IN THE PATUXENT RIVER BASIN (29)

Waters or Water Zones	Water Use To Be Protected
Mainstem and Tributaries	
Headwaters to Brighton Dam	II, III, IV (Trout), V
Brighton Dam to T.H. Duckett Reservoir	II, III, IV (Trout)
T.H. Duckett Reservoir and Tribs.	II, III, IV (Trout)
T.H. Duckett Dam to B & O Railroad	III, IV
B & O Bridge to Queen Annes Bridge	III, IV, V, VI
Queen Annes Bridge to Mouth of Western Branch	III, IV, V
Western Branch to Deep Landing	III, IV
Deep Landing to Swanson Creek	I, III, IV, VI
Swanson Creek to Mouth	I, III, IV, VI
Middle Patuxent and Tributaries	II, III, IV, V, VI
Little Patuxent and Tributaries	
Headwaters to Anne Arundel County Line	II, III, IV, V
Anne Arundel County Line to Mouth	II, III, IV, VI
Western Branch and Tributaries	III, IV, V

ment of Water Resources (MDWR) and the Maryland State Department of Health (MSDH). The MDWR has the authority to control pollution as an integral part of a total program for the development and management of the water resources of the State. The MSDH has "general supervison and control over the waters of the State, insofar as their sanitary and physical conditions affect public health" (21).

In 1966 the General Assembly amended the Annotated Code of the State of Maryland relating to water supply and sewerage planning. According to the amendment, the counties of the State are required to develop by 1970 county master plans to provide for adequate water supply and sewerage systems.

The coordinated county plans will be used as bases for preparing a statewide plan for the enforcement and implementation of the water quality standards. Since each county is required to revise its plan at least annually, continuity in planning on a statewide basis is also provided.

B. INSTITUTIONAL ARRANGEMENTS

An investigation of various institutional arrangements which could be used to initiate and coordinate programs for water and related land resources management was conducted by Mr. Melvin E. Scheidt (1), consultant to the Maryland State Planning Department. Mr. Scheidt was assisted by the Patuxent Basin Technical Task Force of which FWPCA was a member.

The two basic forms of institutional arrangements investigated by this group were:

1. A Patuxent Basin Commission (PBC), and
2. A Patuxent Basin Sanitary Advisory Committee (PBSAC)

An informal advisory committee was recommended as the best and most practical means of coordinating the water quality effort in planning and for providing adequate waste treatment facilities in the basin on a continuing basis.

The advisory committee would include officials of each of the seven counties of the basin plus a representative from the Washington Suburban Sanitary Commission, Washington Metropolitan Council of Governments, Baltimore Regional Planning Council, Maryland State Health Department, and the Maryland Department of Water Resources.

This proposed committee, cooperating with the MSDH and the MDWR, offers a feasible institutional arrangement for preparation of a comprehensive water quality control plan for the Patuxent Basin.

Another proposed arrangement for implementing any adopted water quality management plan in the Patuxent Basin is the Waste Acceptance Service Program (WASP) by the State of Maryland (32). The first phase of a feasibility study on WASP has been completed by Trident Engineering Associates, consultants. The second phase, institutional and legal arrangements, is currently under study. Legislative action by the State of Maryland will be required before the WASP can be implemented. Pending legislative action on WASP, formation of PBSAC should be the first step in a framework for action in the Patuxent Basin. If at a later date the WASP becomes operational, the PBSAC can be readily incorporated into the program.

C. FLOW REGULATION POTENTIAL

There are two existing reservoirs in the Patuxent Basin with an available capacity of about 12.5 billion gallons. These reservoirs were constructed by WSSC for water supply purposes with a dependable monthly uniform total use rate yield of approximately 80 cfs. At a one per cent monthly failure rate, the yield is about 85 cfs (Figure A-5).

The permit issued to the WSSC by the State of Maryland provides for a minimum release of 16.5 cfs or the equivalent of the natural flow of the stream from T.H. Duckett Reservoir.

The Soil Conservation Service (SCS) of the U.S. Department of Agriculture has proposed numerous impoundments and lakes in the Patuxent Basin for water supply, flood prevention, and sediment control (30). Three of these impoundments in the Middle and Little Patuxent Basins could be used for flow regulations for water quality control as well. A description of the three sites with their flow regulation potential and costs are in Tables B-21 and B-22.

D. WASTEWATER TREATMENT POLICIES

In order to obtain the maximum use of the assimilative capacity of the Patuxent River and also meet Maryland water quality standards, a policy of uniform treatment on a noncontinuous basis was utilized for planning purposes in this report. Utilizing this system, the wastes at all plants would receive the same degree of treatment; but the degree of treatment would vary seasonally, depending upon the temperature and volume of flow of the receiving stream. This operating procedure is considered reasonable for this basin since the waste discharge points are concentrated in a relatively short reach of the river where it cannot fully assimilate the effects of one waste discharge before another is introduced.

The criteria used in determining the uniform policy can be either maximum use of assimilative capacity, least-cost wastewater treatment, or by other methods, such as a zonal approach.

In order to be consistent with the adopted Maryland standards and the State implementation plan, the degree of treatment should never be less than 85 per cent removal of carbonaceous BOD.

Preliminary water quality studies in the basin by FWPCA in 1967 indicated the need for a high degree of BOD removal (94 per cent) and possible nutrient removal. This level of treatment would require advanced waste treatment (AWT) and could be accomplished by one of the following alternative methods:

1. Expand existing secondary facilities including provision for AWT;
2. Expand existing secondary facilities and providing AWT at various optimum locations by use of a system of interceptors (this plan calls for piping the secondary effluents); or
3. Abandon some of the existing secondary facilities and provide secondary and AWT at optimum locations via a system of interceptors. (This plan call for piping of the untreated wastewater).

E. ADVANCED WASTEWATER TREATMENT METHODS

To provide for further development of the Patuxent River Basin, complete renovation of municipal wastewater for reuse was taken as the long-range goal in developing the water quality comprehensive program.

In November 1967, the Research Division, FWPCA, was requested to design a treatment sequence or sequences which could produce an effluent with the following chemical characteristics:

Parameter	Concentration	
BOD	< 2	mg/l
DO	> 5	mg/l
Total dissolved solids	<1000	mg/l
Chlorides	< 250	mg/l
Total phosphorus as P	< 0.1	mg/l
Total nitrogen as N	< 2.0	mg/l
Chlorine residual	0.0	mg/l
Coliform count	0	mg/l

The sequence proposed consisted of coagulation and sedimentation, ammonia stripping, rapid sand filtration, and granular activated carbon adsorption. The sequence which is strictly physico-chemical in nature, presents some obvious advantages over biological AWT methods such as the modified activated sludge or biological nitrification-denitrification. The advantages of the physico-chemical system are as follows:

1. Highly fail-safe.
2. More adaptable to complete automation.
3. Adapts readily to modular design and changes.
4. Pilot and plant studies are more advanced at present time than other methods.

5. The processes are not pollutant specific; i.e., in the phosphorus removal module about 60 per cent of the remaining BOD and COD will also be removed. Thus, the unit can be used not only to remove phosphorus but also for obtaining a higher BOD treatment level and the removal of other possible stimulants to algal growth such as vitamins.

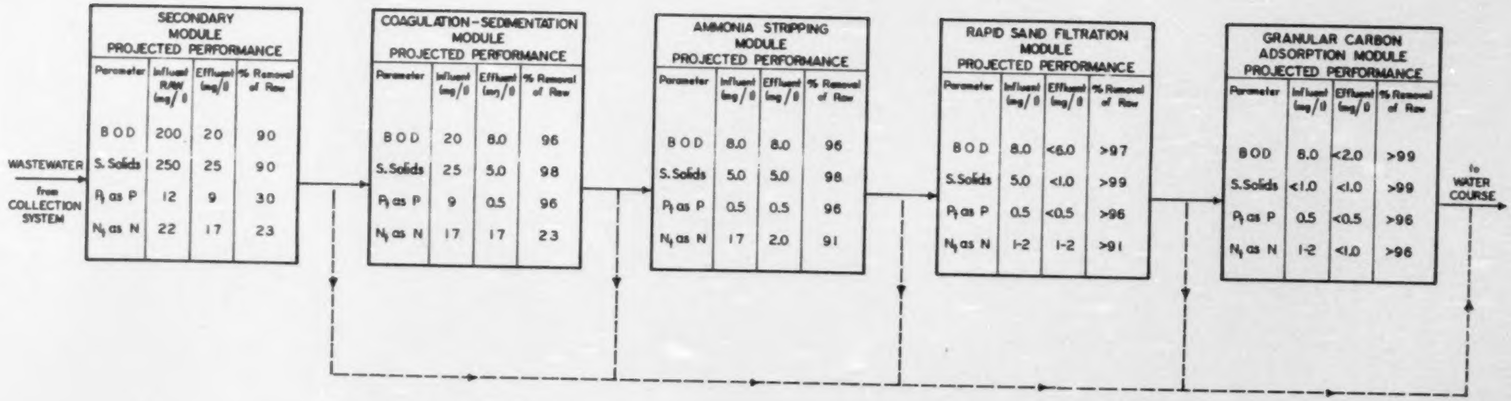
The physico-chemical sequence is similar to the 2.5 mgd plant which is in operation at Lake Tahoe (31) and the 0.3 mgd pilot plant at Washington, D.C. (34).

The sequence as proposed is one of many possible arrangements which could be used in obtaining the prescribed water quality standards. Alternative methods which could be used are the Phosphorus Extraction Process (PEP) for the removal of phosphorus (35), (36) and mixed media filtration instead of rapid sand filtration (37).

The modular design concept of the proposed physico-chemical treatment sequence for the Patuxent River Basin is presented in Figure V-1. Also included in this figure are the anticipated removal levels of the various wastewater pollutants including the anticipated quality of the final effluents from individual units.

PROPOSED MODULAR SEQUENCES
FOR
ADVANCED WASTEWATER TREATMENT

PATUXENT RIVER BASIN



SECONDARY MODULE PROJECTED PERFORMANCE

Parameter	Influent RAW (mg/l)	Effluent (mg/l)	% Removal of Raw
BOD	200	20	90
S. Solids	250	25	90
P_t as P	12	9	30
N_t as N	22	17	23

COAGULATION-SEDIMENTATION MODULE PROJECTED PERFORMANCE

Parameter	Influent (mg/l)	Effluent (mg/l)	% Removal of Raw
BOD	20	8.0	96
S. Solids	25	5.0	98
P_t as P	9	0.5	96
N_t as N	17	17	23

AMMONIA STRIPPING MODULE PROJECTED PERFORMANCE

Parameter	Influent (mg/l)	Effluent (mg/l)	% Removal of Raw
BOD	8.0	8.0	96
S. Solids	5.0	5.0	98
P_t as P	0.5	0.5	96
N_t as N	17	2.0	91

RAPID SAND FILTRATION MODULE PROJECTED PERFORMANCE

Parameter	Influent (mg/l)	Effluent (mg/l)	% Removal of Raw
BOD	8.0	<6.0	>97
S. Solids	5.0	<1.0	>99
P_t as P	0.5	<0.5	>96
N_t as N	1-2	1-2	>91

GRANULAR CARBON ADSORPTION MODULE PROJECTED PERFORMANCE

Parameter	Influent (mg/l)	Effluent (mg/l)	% Removal of Raw
BOD	8.0	<2.0	>99
S. Solids	<1.0	<1.0	>99
P_t as P	0.5	<0.5	>96
N_t as N	1-2	<1.0	>96

FIGURE V-1

CHAPTER VI

WASTEWATER MANAGEMENT CONSIDERATIONS

A. WASTEWATER TREATMENT REQUIREMENTS

1. Requirements With No Additional Flow Regulation

a. Nutrient Removal Requirements for Algal Control

In many respects, the chemical, physical, and biological factors which influence the water quality of the Potomac River Estuary are similar to those affecting the Patuxent Estuary. Although, it is recognized that the algal growth relationships for the Patuxent and Potomac may not be similar in all respects, the nutrient studies conducted in the Potomac River Estuary offer the best base available for establishing nutrient objectives for the Patuxent Estuary. The Sub-Task Force on Water Quality on "Project Potomac" investigated various aspects of maintaining good water quality in the Potomac River, including nutrient removal (38). In order to keep the water essentially free from nuisance growths of rooted aquatic plants, slimes, algae, and other plankton, the Sub-Task Force has suggested a maximum level of 0.1 mg/1 of total phosphorus as P for the Potomac Estuary. Various studies (39) (40) (41) also suggest an upper limit on inorganic nitrogen which may limit algal blooms vary from about 0.05 mg/1 to 0.3 mg/1.

While no definite upper maximums can be statistically supported for all waters at the present time, it appears that if the maximum phosphorus level is kept below 0.1 mg/1 of total phosphorus as P (about 0.33 mg/1 as PO_4) (33) and inorganic nitrogen level below 0.5 mg/1, the water of an estuary will be of such quality as not to stimulate excessive algal growths.* At these levels algal blooms may occur, but not to such an extent as to cause nuisance conditions or increase the organic carbon content as occurs in the environment of the Upper Potomac Estuary. Upper limits of phosphorus as P and inorganic nitrogen as N for waters entering the estuary of 0.1 mg/l and 0.5 mg/l, respectively, were employed in determining nutrient removal requirements.

The water quality standards of the State of Maryland do not at this time set limits on phosphorus and nitrogen levels. However, the intent of the standards as expressed in Section 1.3. (29) is clearly to prohibit the discharge of substances that will contravene adopted standards in waters under the jurisdiction of the State of Maryland. Increased phosphorus and nitrogen levels attributable to sewage which result in excessive algal blooms clearly constitute a nuisance. It is therefore a recommendation of this report that some consideration be given to establishment of maximum nutrient levels as part of the water quality standards of the State of Maryland.

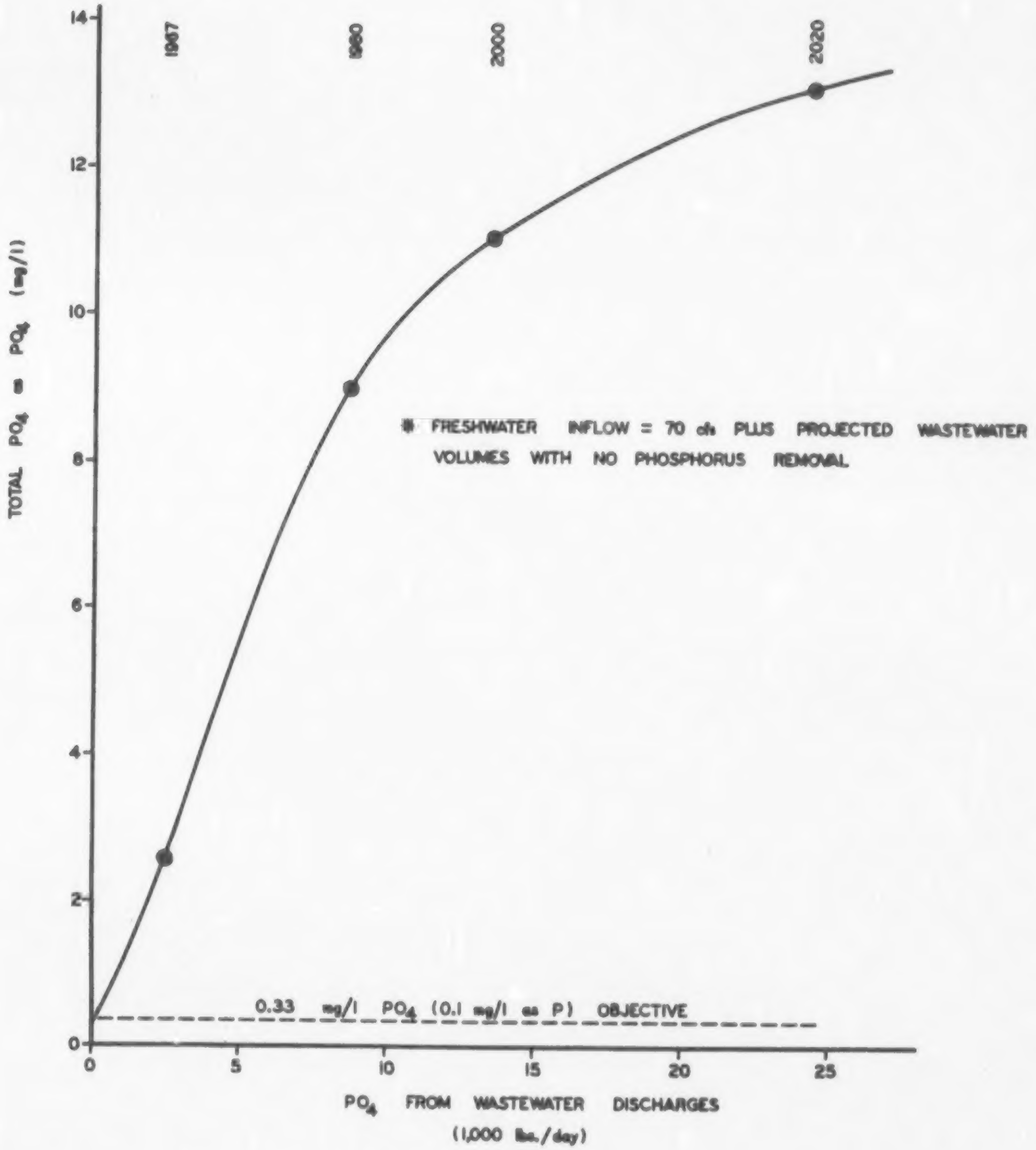
(1) Phosphorus Removal Requirements

As can be seen in Figure VI-1, the total phosphorus as PO_4 entering the estuary is projected to increase from about 2.0 to 13.0 mg/l by the year 2020 for the unregulated design flows. Using a quality

---

* Excessive algal growth is defined as that exceeding 50 mg/l chlorophyll extraction.

PROJECTED PO_4 CONCENTRATION
ENTERING
PATUXENT ESTUARY
FOR
SUMMER CONDITIONS *



* FRESHWATER INFLOW = 70 cfs PLUS PROJECTED WASTEWATER VOLUMES WITH NO PHOSPHORUS REMOVAL

FIGURE VI-1

objective of 0.33 mg/l of PO_4 for water entering the estuary, the removal rate of phosphorus for the waste treatment facilities should be as given in Table VI-1.

Table VI-1

PHOSPHORUS REMOVAL REQUIREMENTS

Year	Projected Concentration Entering Estuary PO_4 as PO_4 (mg/l)	Percent Phosphorus Removal
1980	9.0	96
2000	11.0	97
2020	13.0	98

The cost of phosphorus removal is presented later in the chapter in the section on selection of alternative systems for water quality management.

(2) Nitrogen Removal Requirements

The anticipated total Kjeldahl nitrogen (TKN) loading to the Patuxent System for the three benchmark years of 1980, 2000, 2020, and for 1967 is presented in Table III-3. The amount of nitrogen removal required to meet the suggested nitrogen level of 0.5 mg/l depends on three factors:

(1) the forms of nitrogen in the effluents of the waste treatment plants, (2) the rate of oxidation of the various forms in the stream to nitrates, and (3) the amount of nitrogen fixation occurring in the river system by bacteria and algae.

In the Potomac study (42) (in process), the average TKN and nitrates in the influents were 22.0 and 0.13 mg/l, respectively, with effluent concentrations of 17.0 and 0.67 mg/l, respectively. This represents an average removal of TKN of about 23 percent. While the 1967 data for the Patuxent showed somewhat lower TKN's in the effluent, the nitrates were about two to three-fold higher. The higher nitrates are from those plants which are currently operating below design capacity.

Based on 1967 sampling data as presented in Tables B-11 through B-18 and as exhibited in Figure IV-9, the average nitrite-nitrate concentration of water entering the estuary for summer flows was about 2.0 mg/l. Using a water quality objective of 0.5 mg/l of nitrates and the projected concentration and loadings as presented in Figure VI-2, the removal rates of total nitrogen should be provided as given in Table VI-2.

Table VI-2

NITROGEN REMOVAL REQUIREMENTS

Year	Projected Concentration Entering Estuary NO_3 as N (mg/l)	Percent* Nitrogen Removal
1980	11.0	95
2000	16.0	96
2020	18.0	97

* The removal values were determined by assuming that all the nitrogen discharged from the wastewater treatment plants is in the NH_3 or inorganic form and a large portion is converted to the NO_2 + NO_3 form in the middle portion of the Basin.

PROJECTED INORGANIC NITROGEN CONCENTRATION
ENTERING
PATUXENT ESTUARY
FOR
SUMMER CONDITIONS *

* FRESHWATER INFLOW = 70 cfs PLUS PROJECTED WASTEWATER VOLUME WITH NO NITROGEN REMOVED

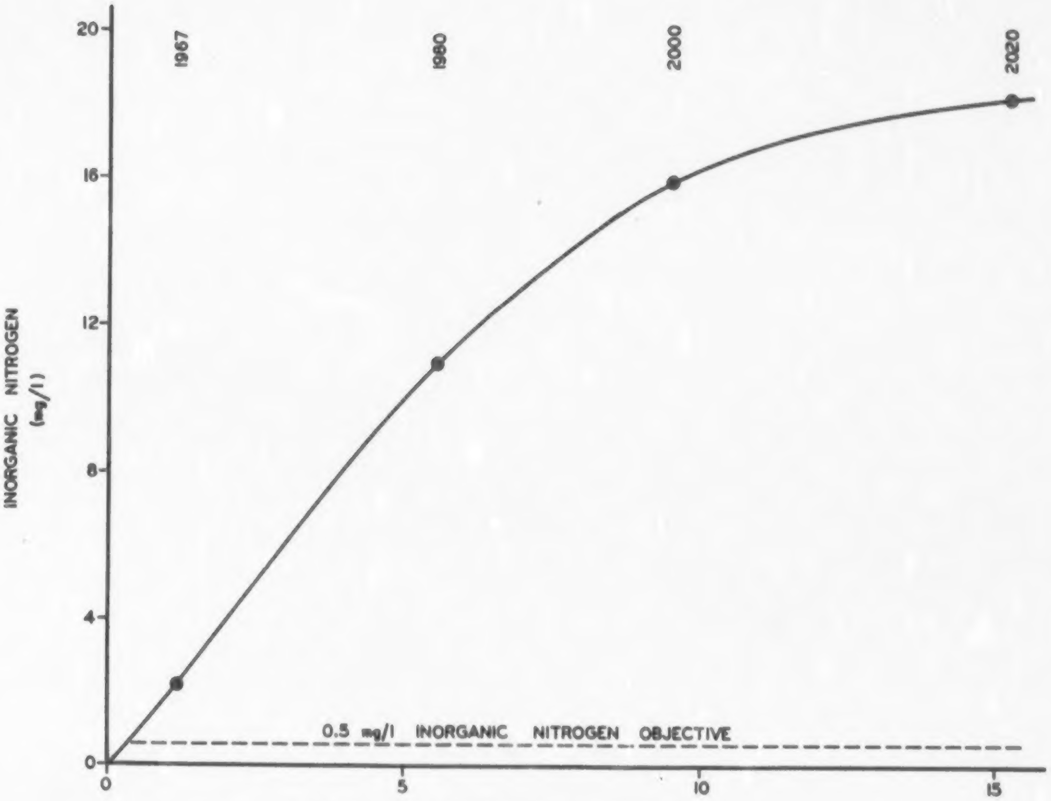


FIGURE VI-2

b. Oxygen Demanding Constituents

As presented in Chapter IV, the two components of the oxygen demand are the residual 5-day BOD (carbonaceous BOD) and the unoxidized nitrogen (nitrogenous BOD) of the discharges from secondary wastewater treatment plants in the basin. The theoretical ultimate oxygen demand (UOD) was determined based on the conversion for carbonaceous and nitrogenous BOD as follows: UOD = 1.45 BOD_5 + 4.57 N (unoxidized nitrogen). The total UOD for the design years are presented in Table VI-3.

Table VI-3

PROJECTED BOD LOADINGS

Year	BOD_5 (lbs/day)	UOD Carbonaceous (lbs/day)	Unoxidized Nitrogen (lbs/day)	UOD Nitrogenous (lbs/day)	Total UOD (lbs/day)
1980	64,300	93,200	5,400	24,700	117,900
2000	101,400	147,000	9,400	43,000	190,000
2020	178,700	258,100	15,300	70,000	328,100

To simplify the determination and presentation of UOD removal requirements, the Patuxent River Basin has been divided into four zones as shown in Figure VI-3.

The project carbonaceous and nitrogenous BOD loadings for Zones I, II, and III, are presented in Table VI-4.

WASTEWATER TREATMENT REMOVAL ZONES

PATUXENT RIVER BASIN

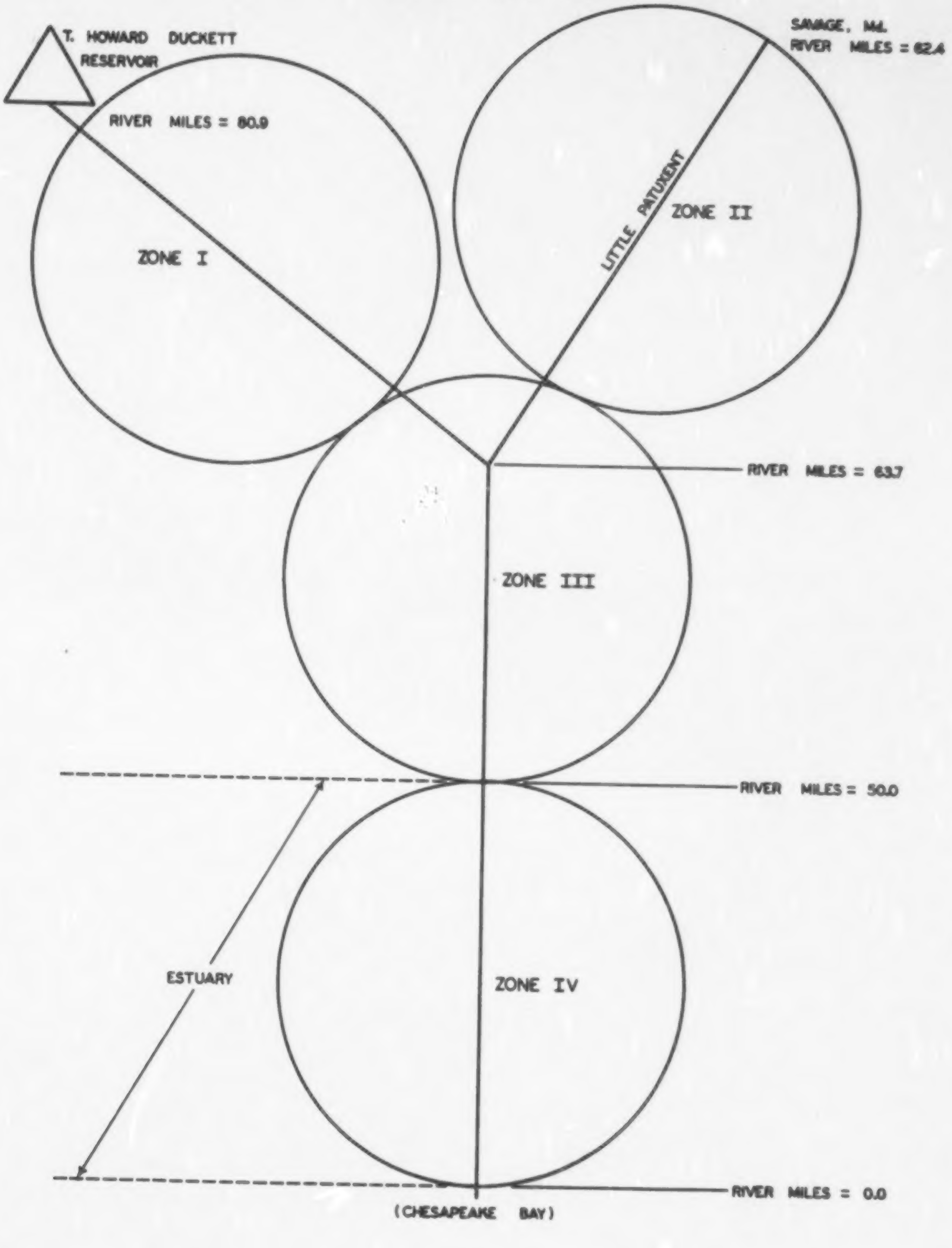

T. HOWARD DUCKETT RESERVOIR
RIVER MILES = 80.9
SAVAGE, Md.
RIVER MILES = 62.4
LITTLE PATUXENT
ZONE I
ZONE II
RIVER MILES = 63.7
ZONE III
RIVER MILES = 50.0
ESTUARY
ZONE IV
RIVER MILES = 0.0
(CHESAPEAKE BAY)

FIGURE VI-3

Table VI-4

PROJECTED BOD LOADINGS BY ZONES (lbs /day)*

	Design Year					
	1980		2000		2020	
	BOD_5	TKN	BOD_5	TKN	BOD_5	TKN
Zone I	11,000	1,100	16,000	1,600	21,000	2,100
Zone II	19,000	2,000	30,000	2,800	57,000	5,300
Zone III	15,000	1,400	21,000	2,100	31,000	3,100

These loadings were determined based on the following premises:

(1) All wastewater being discharged at a single point at the beginning of the zone.

(2) Each zone's response was considered independently.

(3) Deaeration rate of 0.2 and 0.6 (base 10) were employed for the carbonaceous and nitrogenous BOD, respectively.

(4) The reaeration rate was determined using the O'Conner-Dobbins formulation.

Figure IV-4, VI-5 and VI-6 shows the relationship of the amount of unoxidized nitrogen and carbonaceous BOD_5 that could be discharged into zones I, II, and III, and still maintain an average dissolved oxygen level of 5 mg/l. This relationship was determined for two flow conditions in each zone: the lower flow is the flow under natural conditions; the higher flow is what is expected with low flow augmentation. As can be seen in these figures, a dissolved oxygen level of 5 mg/l can be maintained under an almost infinite combination of carbonaceous and nitrogenous loadings.

---

* The loadings are presented in lbs/day of carbonaceous BOD_5 and unoxidized nitrogen.

BOD_5 - NITROGEN LOADINGS IN ZONE I

FOR MAINTAINING AN

AVERAGE of 5.0 mg/l of DISSOLVED OXYGEN

SUMMER CONDITIONS

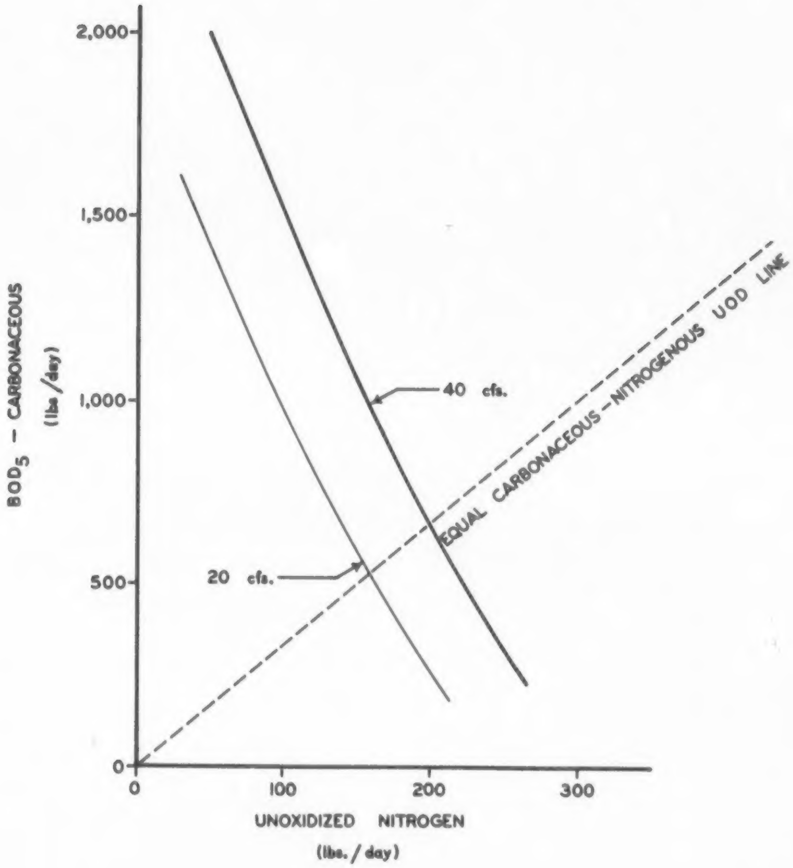
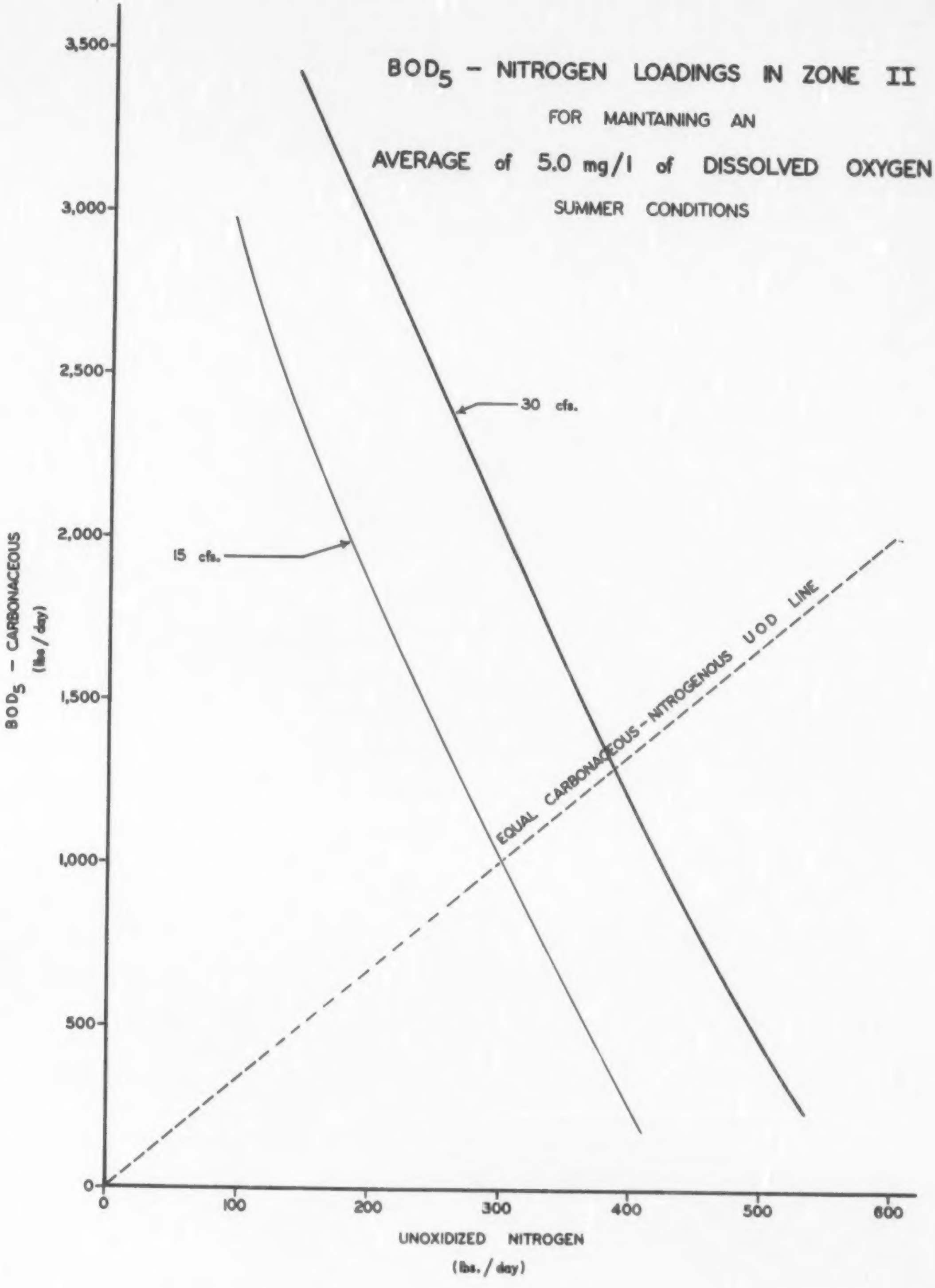


FIGURE VI-4



BOD_5 - NITROGEN LOADINGS IN ZONE II
FOR MAINTAINING AN
AVERAGE of 5.0 mg/l of DISSOLVED OXYGEN
SUMMER CONDITIONS

FIGURE VI-5

BOD$_5$ - NITROGEN LOADINGS IN ZONE III

FOR MAINTAINING AN

AVERAGE of 5.0 mg/l of DISSOLVED OXYGEN

SUMMER CONDITIONS

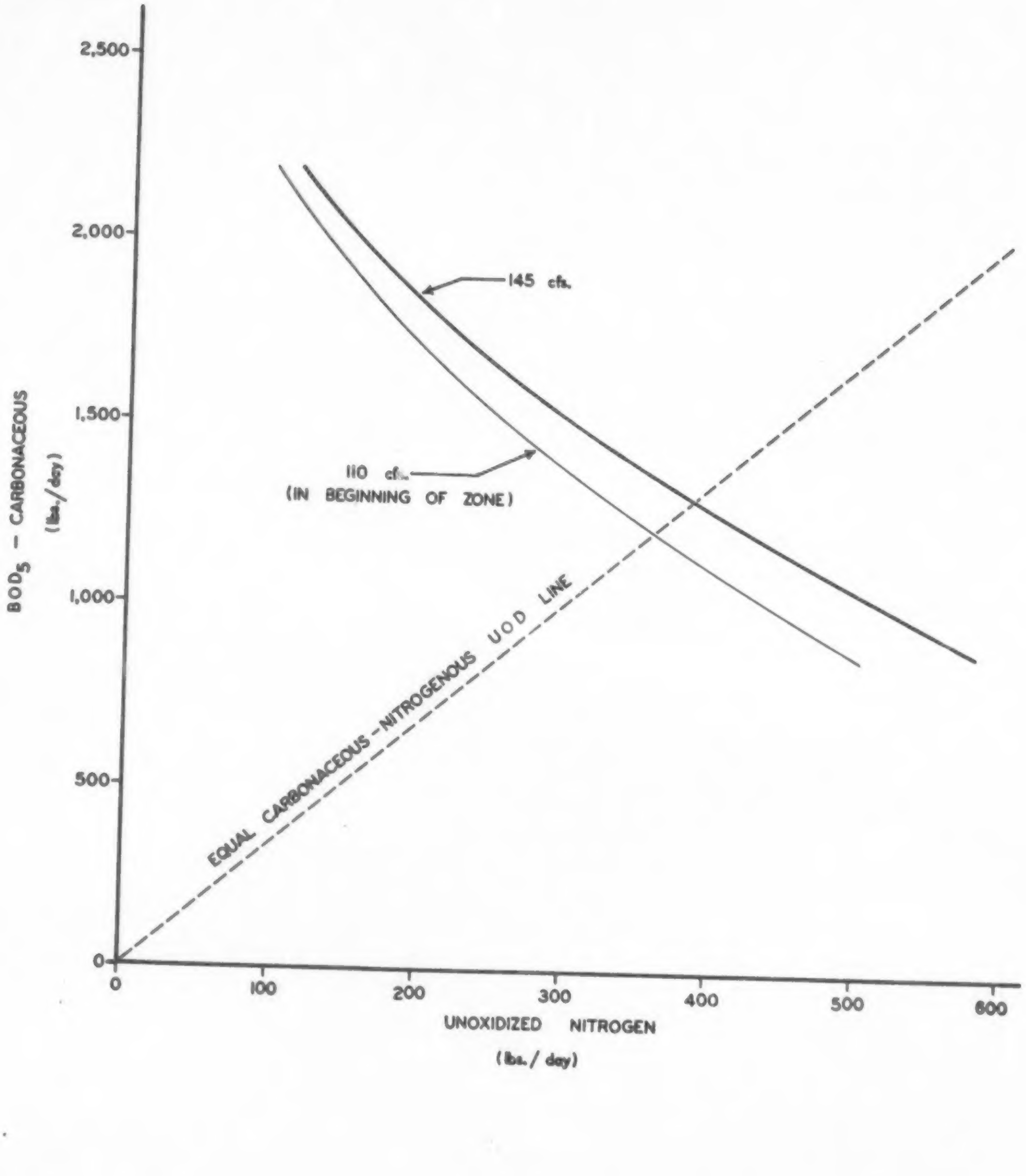


FIGURE VI-6

Also shown on these figures are the lines of equal contributions of carbonaceous and nitrogenous UOD. This line is the graphical representative of the relationship that states that the BOD_u exerted by .317 pounds of unoxidized nitrogen is equal to one pound of carbonaceous BOD_5.

Assuming natural summer flow conditions and also assuming equal residual of both oxygen demand components, i.e., carbonaceous BOD_5 and unoxidized nitrogen, the allowable load of each demand component can be read for each zone at the intersection of the line of equal carbonaceous and nitrogenous UOD and the curve showing the allowable loading. Comparing the allowable loadings at this point on the curve with the projected total waste loadings, the percentage removal of the demand components needed to maintain a dissolved oxygen level of 5 mg/l can be determined for each design year. This information is shown in Table VI-5.

Since there is some pollution carryover from Zones I, and II to Zone III, it was assumed that a uniform treatment practice would be employed in all three zones. This would mean that for any design year, the zone with the most critical treatment requirements would establish the treatment efficiencies in the other two zones. For planning purposes the treatment efficiencies shown in Table VI-6 should be achieved in all three zones.

2. Wastewater Treatment Requirements With Additional Flow Regulation

As indicated earlier in Chapter V the flow regulation capability of the T. Howard Duckett and Tridelphia Reservoirs on the main Patuxent is about 85 cfs and for the proposed SCS reservoir in the Little

Table VI-5

PROJECTED BOD AND NITROGEN REMOVAL REQUIREMENTS BY ZONES*

PATUXENT RIVER BASIN
Summer Conditions

	ZONE I		ZONE II		ZONE III	
Year	Removal of BOD	Removal of TKN	Removal of BOD	Removal of TKN	Removal of BOD	Removal of TKN
1980	95	86	95	85	92	75
2000	96	90	96	89	94	83
2020	97	92	98	94	96	89

* Based on an equal removal of both demand components

Table VI-6

OXYGEN DEMANDING MATERIAL REMOVAL REQUIREMENTS

Year	Carbonaceous BOD	Nitrogenous BOD
1980	95	86
2000	96	90
2020	98	94

Patuxent about 45 cfs. The 7-day low flows with recurrence interval of once in ten years for the main Patuxent and Little Patuxent unregulated areas are 12.0 and 9.2 cfs respectively.

If the existing reservoirs on the main Patuxent and the proposed SCS impoundments are used solely for water quality control, the 7-day low flow entering the estuary can be increased from about 70 cfs to 180 cfs. With the maximum flow capacity utilized for water quality control, the concentrations of phosphorus and nitrites are projected to be about 3.5 and 5.5 mg/l respectively during low flow conditions for the 1980 design year. Even with the increased flow rates into the estuary, about 91 percent removal of both phosphorus and nitrogen should be provided by 1980 in order to meet water quality objectives.

As can be seen in Figures VI-4, and VI-5, and VI-6, the effect of increased flows on the amount of wastewater that can be assimulated is relatively small, especially in Zone III, and that this alternative approach is also ineffective in maintaining adopted water quality standards.

3. Wastewater Requirements for Tidal Water

a. Municipal Discharges

The lower portion of the Patuxent Estuary has been divided into four wastewater areas (Figure A-6). The projected populations for these four areas are given below:

Table VI-7

POPULATION PROJECTIONS FOR LOWER PATUXENT BASIN

Area	Projected Population 1980	2000	2020
Rural Prince Georges County	7,700	10,000	13,000
Rural Calvert County	10,500	18,500	32,600
Rural Charles County	2,800	3,300	4,000
St. Marys County	35,000	42,000	50,000

To meet the wastewater treatment and water supply needs of these counties, master plans are currently being developed. A listing of treatment plants, proposed, existing, and under construction, is given in Table VI-8. Since the wastewater discharge points are either to the estuary itself or to tributaries which flow into the Chesapeake Bay, no estimates were made of treatment requirements or costs. A more comprehensive approach can be made once a mathematical model of the estuary is developed as indicated earlier in this report.

Table VI-8

WASTEWATER TREATMENT PLANTS, EXISTING, PROPOSED, AND UNDER CONSTRUCTION IN LOWER PATUXENT RIVER BASIN

Plant	County	Discharge Location	Design Capacity	Remarks
Pine Hill Run	St. Marys Charles	Pine Hill Run to Chesapeake Bay	3.0	Under construction
Golden Beach	St. Marys	Patuxent Estuary	-	Proposed plant with Charles County
Queentree Sanitation District	St. Marys	Patuxent Estuary	-	Proposed
Prince Frederick	Calvert	Patuxent Estuary	-	Proposed
Northern Calvert County	Calvert	Patuxent Estuary	-	Proposed housing development
Naval Ordinance Lab	Calvert	Tributary to Chesapeake Bay	-	Serves surrounding area

b. Industrial Discharges

The only significant industrial waste discharge into the lower estuary is from the PEPCO Chalk Point thermal electric generating station. At the present time, the water quality standards in regard to temperature are being met. As in the case of municipal treatment requirements, the effects of wastewater discharges from any industrial development cannot be fully evaluated until a mathematical model of the estuary is developed.

B. WASTEWATER MANAGEMENT SYSTEMS AND SELECTION FACTORS

Systems considered for wastewater management in the Patuxent River Basin were as follows:

Effluent discharge within the basin with no additional flow regulation,

Effluent discharge within the basin including additional flow regulation,

Effluent transport to the Chesapeake Bay, and

Waste transport to the Atlantic Gulf Stream.

Although the fourth,waste transport to the Atlantic Gulf Stream, was considered, a detailed evaluation of this management system was beyond the scope of this report.

1. Effluent Discharge Within the Basin With No Additional Flow Regulation

As presented in the first part of this chapter, the removal of about 95 percent of the BOD, nitrogen, and phosphorus will be required by 1980. Conventional wastewater treatment would not meet the water quality objective for the basin. Thus, to provide these removal requirements, advanced wastewater treatment facilities such as described in Chapter V will be required.

2. Effluent Discharge Within the Basin Including Additional Flow Regulation

To meet the DO objective of 5.0 mg/l, a high degree of both carbonaceous and nitrogenous removal will be required by 1980 even with increased flow regulation as shown in Figures VI-4, VI-5, and VI-6. Coupled within the need for nutrient removal, even with flow regulation, it appears that any benefit derived from the increased flow will be insignificant. Since the existing reservoirs are mainly used for water supply and advanced wastewater will be required in any case. Low flow augmentation does not appear to have merit at the present time.

3. Wastewater Treatment With Effluent Transport To Chesapeake Bay

In developing the Regional Sewerage Plan for the Patuxent River Basin, Wolman, Geyer, and Beavin (26) investigated the possibility of disposing of all the basin's treated effluent to the Chesapeake Bay. The bay outfall, which was jointly planned with the District of Columbia Government, was feasible from the engineering standpoint and would be reasonable in cost. However, the project was not recommended for adoption in the near future, nor probably before the year 2000, for the following reasons as given by Wolman, Geyer, and Beavin:

1. "The single system costing the basin about $53,000,000 would not lend itself readily to stage construction, and the necessary financing would be difficult."
2. "The bay outfall projected from the Washington, D.C. area is not certain to materialize. The cost of the system for the

Patuxent Basin alone would add about $7,000,000 to the project."

3. "Disposal to the bay would not utilize the natural asset of the Patuxent River's assimilative capacity."

A more recent study of the wastewater treatment problem in the Patuxent Basin has been made by Trident Engineering Associates, Inc. (32). Using the Wolman, Geyer, and Beavin Report as a basis of design, the consulting firm also investigated disposal to Chesapeake Bay. Costs for four alternative methods of disposal into the bay as developed by Trident Engineering Associates as given in Table VI-9.

Table VI-9

COST OF DISPOSAL TO CHESAPEAKE BAY
Trident Engineering Associates, Inc.

Bay Interceptor		BOD Removal Requirements		Total Cost
With D.C.	Without D.C.	65%	90%	
X		X		$32,260,000
X			X	40,666,000
	X	X		46,560,000
	X		X	51,560,000

The costs of the four alternatives in this table include an interceptor upstream and outfall capable of transporting all wastewater in the basin up to the year 2000.

Since the report of Wolman, Geyer, and Beavin was written, information on water quality in the Bay itself reveals that it is already nutrient rich (33). Futhermore, it appears that in the near future all wastewater discharged into the bay may require a high degree of nutrient removal. The cost of disposal to the bay, including advanced wastewater treatment (AWT) for nutrient and high degree of BOD removal, is presented in the latter part of this chapter.

C. ADVANCED WASTE TREATMENT WITH DISCHARGE WITHIN THE BASIN

There are eight major operating municipal waste treatment facilities in the basin. In addition, one facility is under construction, and one proposed. Industrial wastewater volumes are small and were not included in the cost analysis. Nine sites for treatment of the wastewater from the eleven services presented in Table VI-10 were considered for this study. The combining of systems and a summary of the projected wastewater volumes of the nine areas are given in Table VI-11.

Four alternative plans for providing advanced waste treatment facilities were investigated and are presented in Figures VI-7 thru VI-10. The four plans, which are based on providing advanced waste treatment at a given number of sites with secondary treatment at each of the existing or proposed sites, are also given in Table VI-11.

Summaries of modular unit costs for Plan A, B, C, and D are presented in Tables VI-12 through VI-15. The present worth cost data include capital expenditures based on 1970 and 1980 construction staging, and expenditures for operation and maintenance. The present worth cost for operations and maintenance was divided into two operating periods, 1970-1980 and 1980-2000. The detailed cost data for individual modular units of each plan are presented in Appendix Tables C-1 through C-10.

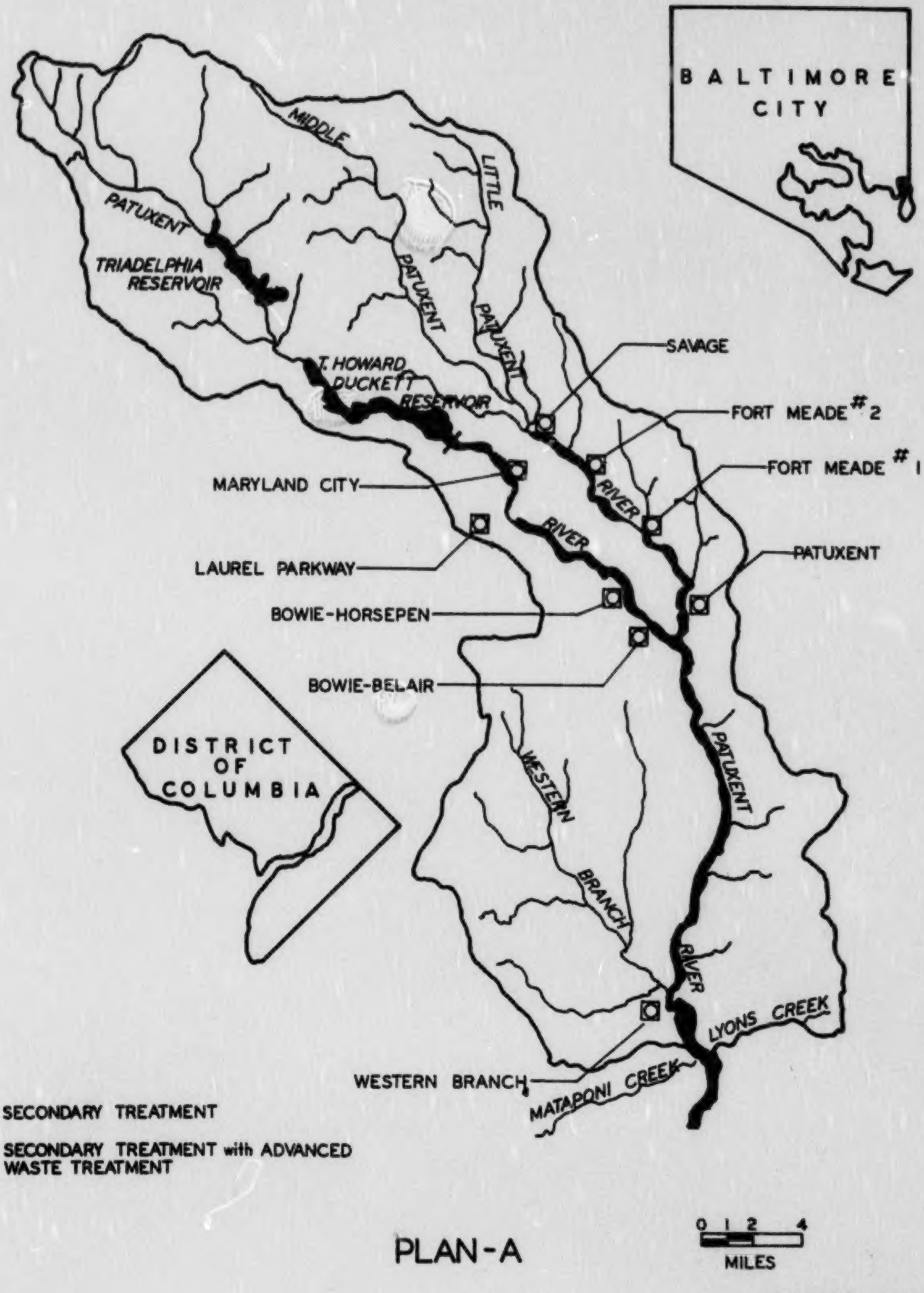
Table VI-10

CURRENT DESIGN CAPACITY AND SUMMARY OF PROJECTED WASTEWATER VOLUMES FOR THE YEARS 1980, 2000, and 2020 UPPER PATUXENT RIVER BASIN

Facility	Current Design Capacity (mgd)	Projected Wastewater Volumes (mgd) 1980	2000	2020
Maryland City (Md. House of Correction)	0.75	1.9	2.4	3.1
Laurel Parkway	2.40	6.4	9.7	13.0
Bowie-Horsepen*	0.00	2.1	4.1	6.7
Bowie-Belair	2.40	3.4	5.0	6.6
Savage	1.00	7.3	15.0	31.6
Ft. G.G. Meade #2	2.50	1.8	2.2	2.6
Ft. G.G. Meade #1	1.50	1.4	1.8	2.2
Patuxent	2.00	4.5	6.0	8.1
Western Branch** (Marlboro Meadows) (Rural Anne Arundel)	0.00	7.1	15.5	33.3
Total	12.55	35.9	61.7	107.2

* Includes U.S. Government projections.

** The Western Branch treatment facility with a capacity of 5.0 mgd is currently under construction. The cost analysis includes both the capital and operating and maintenance costs for the Western Branch plant.

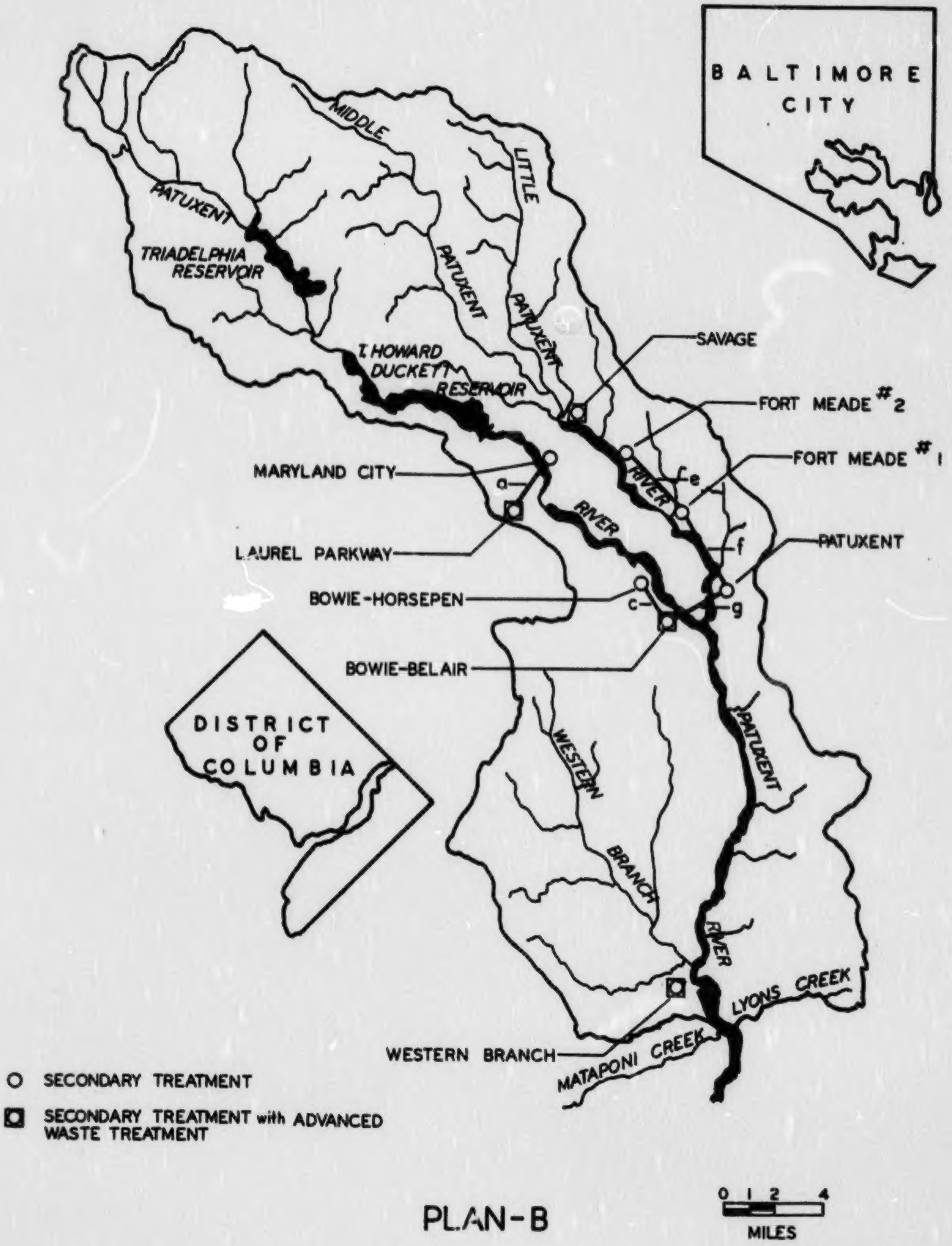

BALTIMORE CITY
MIDDLE
LITTLE
PATUXENT
PATUXENT
PATUXENT
TRIADELPHIA RESERVOIR
T. HOWARD DUCKETT RESERVOIR
SAVAGE
FORT MEADE #2
FORT MEADE #1
MARYLAND CITY
RIVER
RIVER
LAUREL PARKWAY
PATUXENT
BOWIE-HORSEPEN
BOWIE-BELAIR
DISTRICT OF COLUMBIA
WESTERN BRANCH
PATUXENT
RIVER
LYONS CREEK
WESTERN BRANCH
MATAPONI CREEK
0 1 2 4
MILES

○ SECONDARY TREATMENT

▣ SECONDARY TREATMENT with ADVANCED WASTE TREATMENT

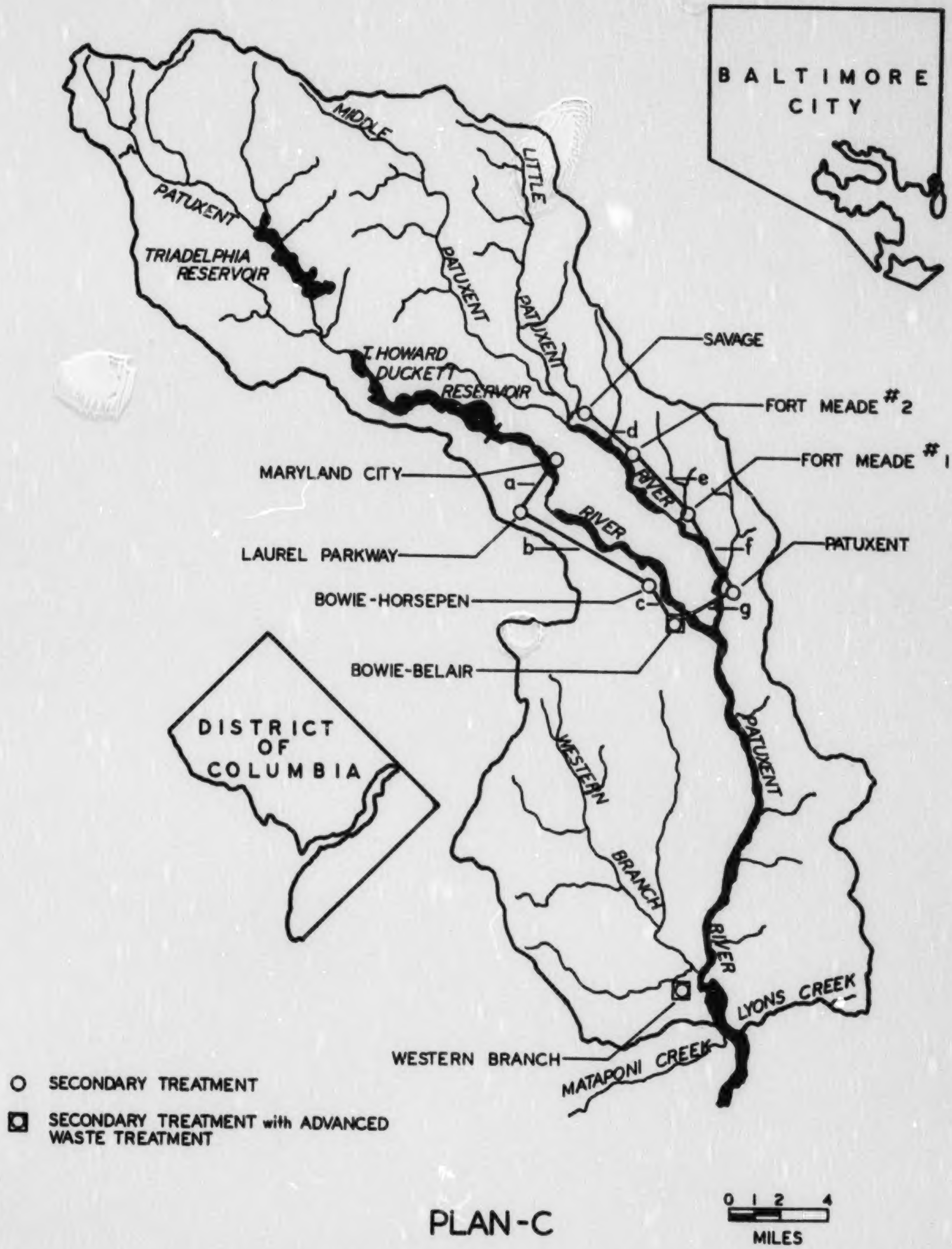
PLAN-A

FIGURE VI-7


BALTIMORE CITY
MIDDLE
LITTLE
PATUXENT
TRIADELPHIA RESERVOIR
PATUXENT
PATUXENT
T. HOWARD DUCKETT RESERVOIR
SAVAGE
FORT MEADE #2
FORT MEADE #1
MARYLAND CITY
a
e
RIVER
RIVER
LAUREL PARKWAY
f
PATUXENT
BOWIE-HORSEPEN
c
g
BOWIE-BELAIR
DISTRICT OF COLUMBIA
WESTERN
BRANCH
PATUXENT
RIVER
LYONS CREEK
WESTERN BRANCH
MATAPONI CREEK
SECONDARY TREATMENT
SECONDARY TREATMENT with ADVANCED WASTE TREATMENT
0 1 2 4
MILES

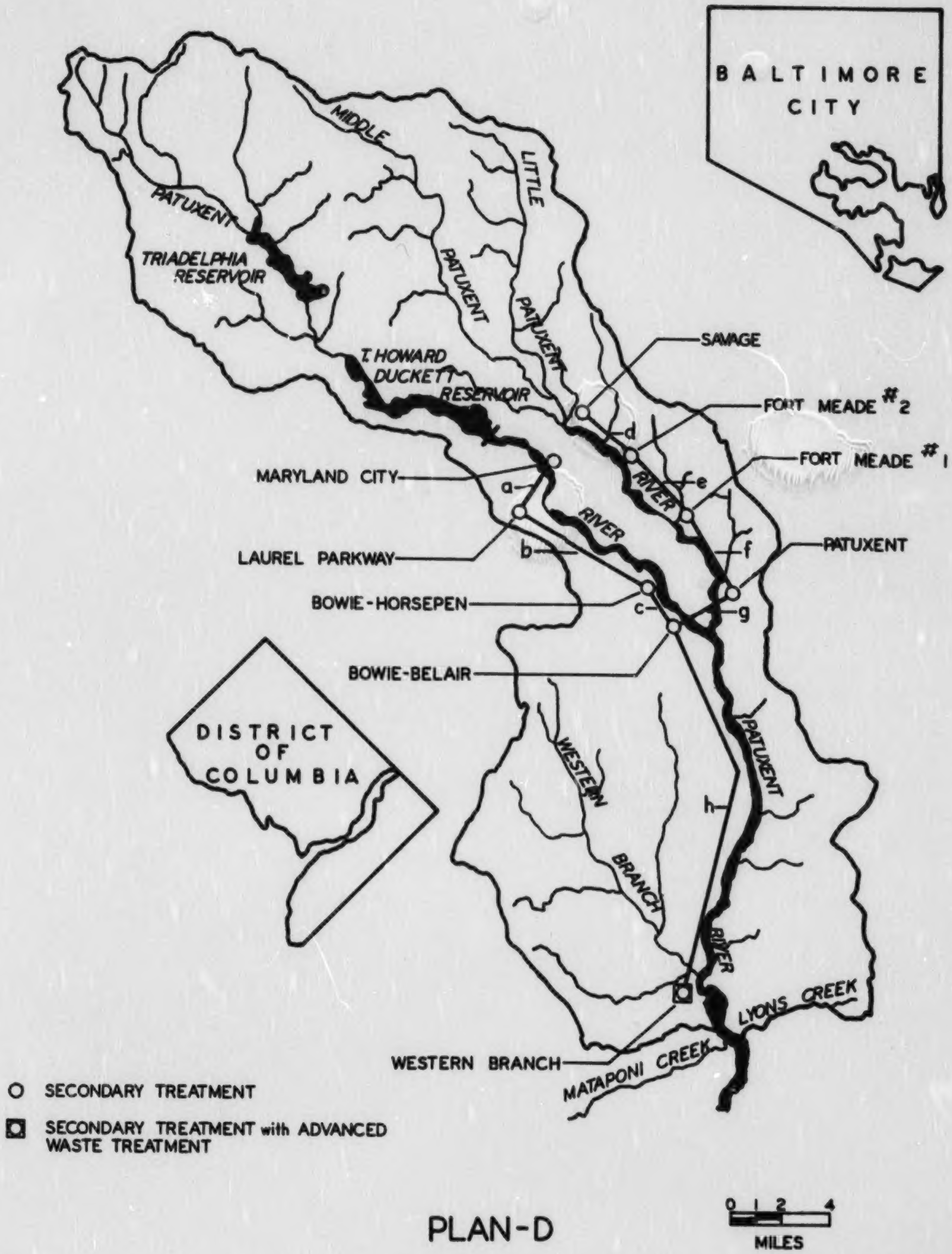
PLAN-B

FIGURE VI-8


BALTIMORE CITY
MIDDLE
LITTLE
PATUXENT
TRIADELPHIA RESERVOIR
PATUXENT
PATUXENT
T. HOWARD DUCKETT RESERVOIR
SAVAGE
FORT MEADE #2
FORT MEADE #1
MARYLAND CITY
a
b
c
d
e
f
g
RIVER
RIVER
LAUREL PARKWAY
PATUXENT
BOWIE-HORSEPEN
BOWIE-BELAIR
DISTRICT OF COLUMBIA
WESTERN
BRANCH
PATUXENT
RIVER
LYONS CREEK
WESTERN BRANCH
MATAPONI CREEK
○ SECONDARY TREATMENT
▣ SECONDARY TREATMENT with ADVANCED WASTE TREATMENT
0 1 2 4
MILES

PLAN-C

FIGURE VI-9


BALTIMORE CITY
MIDDLE
PATUXENT
LITTLE
PATUXENT
TRIADELPHIA RESERVOIR
PATUXENT
T. HOWARD DUCKETT RESERVOIR
SAVAGE
FORT MEADE #2
d
RIVER
FORT MEADE #1
e
MARYLAND CITY
a
LAUREL PARKWAY
b
RIVER
f
PATUXENT
BOWIE-HORSEPEN
c
g
BOWIE-BELAIR
DISTRICT OF COLUMBIA
WESTERN BRANCH
PATUXENT
h
RIVER
LYONS CREEK
WESTERN BRANCH
MATAPONI CREEK
○ SECONDARY TREATMENT
■ SECONDARY TREATMENT with ADVANCED WASTE TREATMENT
0 1 2 4
MILES

PLAN-D

FIGURE VI-10

Table VI-11

ALTERNATIVE WASTEWATER TREATMENT SYSTEMS

AWT Systems	Design Volumes (mgd) 1970-1980	1980-2000	Secondary Systems
PLAN A (Figures VI-7)			
Maryland City	2.5	3.0	Maryland City (Md. House of Correction)
Laurel Parkway	6.4	9.9	Laurel Parkway
Bowie-Horsepen	2.0	4.0	Bowie-Horsepen
Bowie-Belair	4.0	5.5	Bowie-Belair
Savage	8.0	15.0	Savage
Ft. G.G. Meade #2	2.5	2.5	Ft. G.G. Meade #2
Ft. G.G. Meade #1	1.5	3.0	Ft. G.G. Meade #1
Patuxent	4.5	6.0	Patuxent
Western Branch	8.0	16.0	Western Branch (Marlboro Meadows) (Rural Anne Arundel)
PLAN B (Figures VI-8)			
Laurel Parkway	9.0	13.0	Laurel Parkway Maryland City (Md. House of Correction)
Savage	8.0	15.0	Savage
Bowie-Belair	14.0	20.0	Patuxent, Ft. G.G. Meade #2 Ft. G.G. Meade #1 Bowie-Horsepen Bowie-Belair
Western Branch	8.0	16.0	Western Branch (Marlboro Meadows) (Rural Anne Arundel)

Table VI-11 (Continued)

AWT Systems	Design Volumes (mgd) 1970-1980	 1980-2000	Secondary Systems
PLAN C (Figures VI-9)			
Bowie-Belair	30.0	47.0	Savage Ft. G.G. Meade #2 Ft. G.G. Meade #1 Patuxent Maryland City (Md. House of Correction) Laurel Parkway Bowie-Horsepen Bowie-Belair
Western Branch	8.0	16.0	Western Branch (Marlboro Meadows) (Rural Anne Arundel)
PLAN D (Figures VI-10)			
Western Branch	38.0	63.0	Savage Ft. G.G. Meade #2 Ft. G.G. Meade #1 Patuxent Maryland City (Md. House of Correction) Laurel Parkway Bowie-Horsepen Bowie-Belair Western Branch (Marlboro Meadows) (Rural Anne Arundel)

Table VI-12

COST SUMMARY OF MODULAR UNITS FOR PLAN A
FOR WASTEWATER TREATMENT

for the years
1970-2000

Modular Design Units						Present Worth Cost (1970)		
Interceptor	Secondary	No. 1 Coagulation and Sedimentation	No. 2 Ammonia Stripping	No. 3 Rapid Sand Filtration	No. 4 Granular Carbon Adsorption	Capital ($1000)	Operating and Maintenance ($1000)	Total Cost ($1000)
-						0	0	0
-	x					20,650	16,335	36,985
-	x	x				23,100	25,140	48,240
-	x	x	x			25,350	28,510	53,860
-	x	x	x	x		28,290	37,990	66,280
-	x	x	x	x	x	40,330	56,510	96,840

Table VI-13

COST SUMMARY OF MODULAR UNITS FOR PLAN B FOR WASTEWATER TREATMENT

for the years
1970-2000

Modular Design Units						Present Worth Cost (1970)		
Interceptor	Secondary	No. 1 Coagualtion and Sedimentation	No. 2 Ammonia Stripping	No. 3 Rapid Sand Filtration	No. 4 Granular Carbon Adsorption	Capital ($1000)	Operating and Maintenance ($1000)	Total Cost ($1000)
x						1,610	0	1,610
x	x					22,260	16,335	38,595
x	x	x				24,470	24,875	49,345
x	x	x	x			26,280	28,065	54,345
x	x	x	x	x		28,660	35,345	64,005
x	x	x	x	x	x	37,920	50,355	88,275

Table VI-14

COST SUMMARY OF MODULAR UNITS FOR PLAN C
FOR WASTEWATER TREATMENT

for the years
1970-2000

Modular Design Units						Present Worth Cost (1970)		
Interceptor	Secondary	No. 1 Coagulation and Sedimentation	No. 2 Ammonia Stripping	No. 3 Rapid Sand Filtration	No. 4 Granular Carbon Adsorption	Capital ($1000)	Operating and Maintenance ($1000)	Total Cost ($1000)
x						4,990	0	4,990
x	x					25,640	16,335	41,975
x	x	x				27,600	24,540	52,140
x	x	x	x			29,210	27,580	56,790
x	x	x	x	x		30,010	32,980	62,990
x	x	x	x	x	x	37,830	45,190	83,020

Table VI-15

COST SUMMARY OF MODULAR UNITS FOR PLAN D FOR WASTEWATER TREATMENT

for the years
1970-2000

Modular Design Units						Present Worth Cost (1970)		
Interceptor	Secondary	No. 1 Coagulation and Sedimentation	No. 2 Ammonia Stripping	No. 3 Rapid Sand Filtration	No. 4 Granular Carbon Adsorption	Capital ($1000)	Operating and Maintenance ($1000)	Total Cost ($1000)
x						12,490	0	12,490
x	x					33,140	16,335	49,475
x	x	x				35,040	24,185	59,225
x	x	x	x			36,540	27,320	63,860
x	x	x	x	x		38,040	31,570	69,610
x	x	x	x	x	x	43,440	41,870	85,310

The interceptor and pumping costs are given in Table C-11. The merits and cost of each alternative are discussed separately in the next chapter. Present worth cost calculations were made using a 4 ½ percent interest rate over a 30-year amortization period.

D. ADVANCED WASTE TREATMENT WITH DISCHARGE TO CHESAPEAKE BAY

Presented in Table VI-16 is Plan E which is the cost of disposal to the bay including advanced wastewater treatment (AWT) for nutrient and high degree of BOD removal. (See Figure VI-11 for Plan E)

Table VI-16

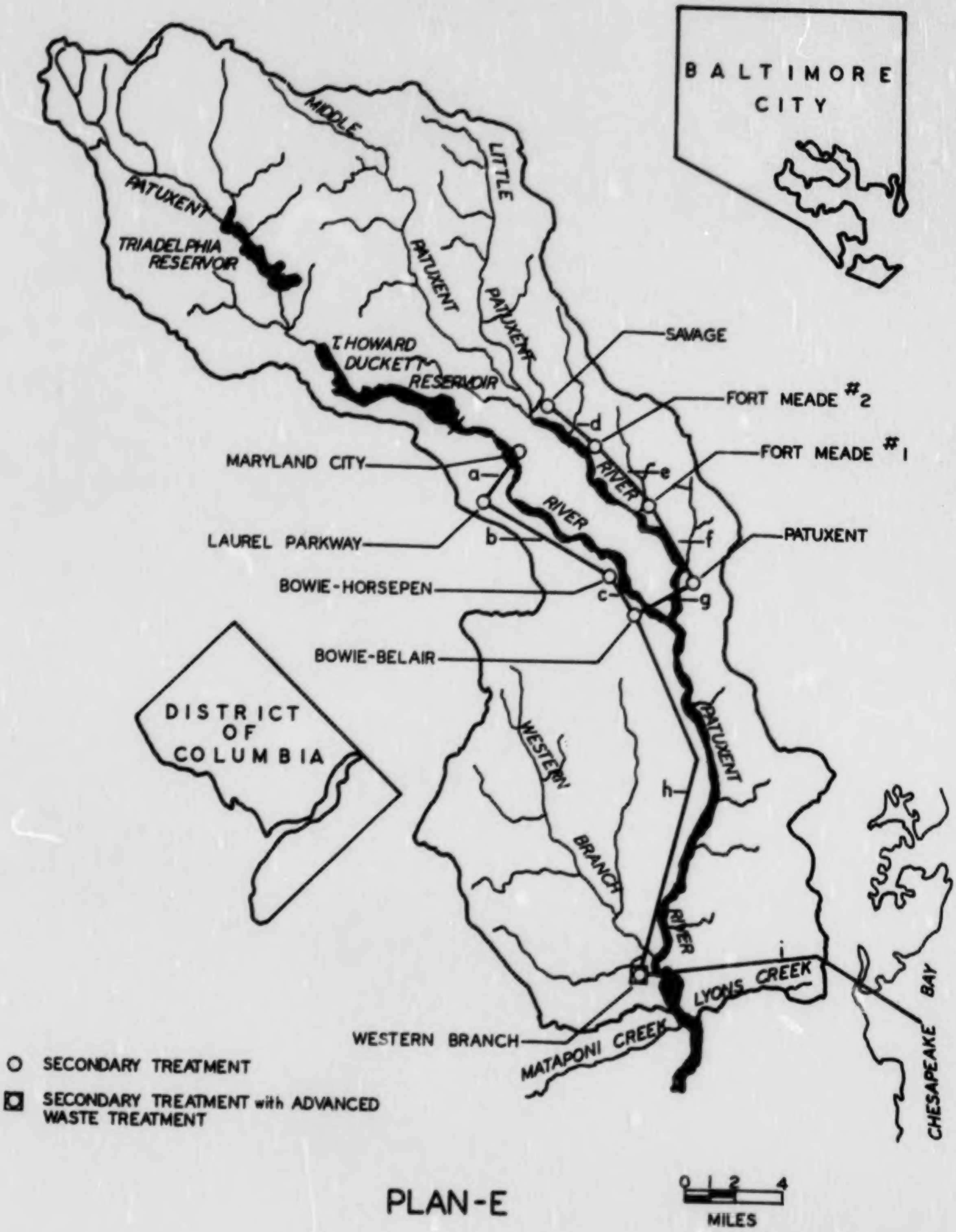
PLAN E

COST OF DISPOSAL TO CHESAPEAKE BAY
Including Advanced Wastewater Treatment

Secondary Treatment* and Plant Interceptors	Bay Interceptor	Phosphorus Removal	Ammonia Stripping	Rapid Sand Filtration	Activated Carbon	Total Present Worth Cost ($1000)
x						$47,575
x	x					57,795
x	x	x				67,545
x	x	x	x			72,180
x	x	x	x	x		77,930
x	x	x	x	x		93,630

* Cost of providing secondary treatment and interceptors for the period 1970-2000 as developed for Plan D.

In the above table, it is assumed that secondary treatment is provided at the existing water service areas.


BALTIMORE CITY
PATUXENT
MIDDLE
LITTLE
TRIADELPHIA RESERVOIR
PATUXENT
PATUXENT
T. HOWARD DUCKETT RESERVOIR
SAVAGE
FORT MEADE #2
d
FORT MEADE #1
e
MARYLAND CITY
a
RIVER
RIVER
LAUREL PARKWAY
b
f
PATUXENT
BOWIE-HORSEPEN
c
g
BOWIE-BELAIR
DISTRICT OF COLUMBIA
WESTERN
BRANCH
PATUXENT
h
RIVER
i
LYONS CREEK
WESTERN BRANCH
MATAPONI CREEK
CHESAPEAKE BAY
○ SECONDARY TREATMENT
▣ SECONDARY TREATMENT with ADVANCED WASTE TREATMENT
0 1 2 4
MILES

PLAN-E

FIGURE VI-11

E. SELECTION OF A MANAGEMENT SYSTEM

From an analysis of the treatment requirements and effects of flow regulation, it appears that a very high degree of wastewater renovation including nutrient removal will be necessary by 1980. While better analytical techniques may refine the treatment requirement calculations, it has been well established that both the nitrogenous and carbonaceous demand must be removed. Moreover, nutrient and chlorophyll data indicate that the upper estuary is becoming eutrophic.

Advanced waste treatment with discharge within the basin, appears to be the most feasible program for water quality management in the basin. While the total cost is high, the construction of the treatment facilities can be done in stages, facilitating the financing of the projects. Also in utilizing a staging system, the design of the facilities can be readily adapted to new technologies and waste treatment requirements. For example; if a low phosphorus content detergent is developed a revaluation of the phosphorus removal requirements can be readily made.

CHAPTER VII

SELECTION OF AN ADVANCED WASTE TREATMENT PROGRAM

A. PLANNING ALTERNATIVES

Advanced waste treatment (AWT) of wastes, for the reasons discussed in Chapter VI, appears to be the most feasible alternative for maintaining acceptable water quality in the Patuxent River Basin. Four basic plans for achieving AWT in the basin are discussed in this chapter.

In developing the four plans, it was assumed that the capacity of the existing secondary treatment plants would be expanded. AWT could then be provided at existing secondary plants or the secondary effluent conveyed via interceptors to regional waste treatment facilities in strategic locations. The elements involved in the four basic plans are as follows:

Plan A- 9 secondary systems and 9 AWT systems
Plan B- 9 secondary systems and 4 AWT systems
Plan C- 9 secondary systems and 2 AWT systems
Plan D- 9 secondary systems and 1 AWT system

A modification of Plan D, Plan D*, was also investigated. This plan considers the abandonment of all existing secondary systems and the construction of a single secondary plant and AWT units near Western Branch to treat all wastewater from the Upper Basin.

The specific treatment plants included in each of the plans are identified in Table VI-11 and Figures VI-7 thru 10. In this chapter each of the plans is evaluated in relation to the following criteria:

1. Costs, including capital and operation-maintenance cost;
2. Tangible and intangible factors;
3. Institutional arrangement considerations;
4. Engineering and technical feasibility;

and discussed in detail under the appropriate headings.

1. Cost Comparisons

Summaries of the modular unit costs for Plans A, B, C, and D are given in Tables VI-12 through VI-15. Table VII-1 presents a cost ranking of the four plans based on financial considerations.

As can be seen in Table VII-1, for the first and second modular waste treatment units, Plan A is the least cost solution. When the third and fourth units are added, Plan C is the most economical.

Two other factors which should be considered in selecting a given treatment sequence are: (1) the effect of combining effluents on the overall water quality in the river, and (2) the staging of the treatment levels needed to maintain the prescribed objectives of the comprehensive program. The BOD removal requirements will be, to some extent, a function of the number and location of discharge points within the Basin. The more evenly the wastewater is distributed within the system, the more use is made of the natural assimilative capacity of the receiving stream. Nevertheless, a high degree of removal of both phosphorus and nitrogen will be required to protect the estuary regardless of the wastewater effluent distribution.

Table VII-1

COST COMPARISONS OF VARIOUS MODULAR SEQUENCES WITH DISPOSAL WITHIN THE BASIN

Modular Units				Plan Ranking by Present Worth Cost (Lowest to Highest)							
				1st		2nd		3rd		4th	
Coagulation and Sedimentation	Ammonia Stripping	Rapid Sand Filtration	Granular Carbon Adsorption	Plan	Cost ($1000)	Plan	Cost ($1000)	Plan	Cost ($1000)	Plan	Cost ($1000)
X				A	$48,240	B	$49,345	C	$52,140	D	$59,225
X	X			A	53,860	B	54,345	C	56,790	D	63,860
X	X	X		C	62,990	B	64,005	A	66,280	D	69,610
X	X	X	X	C	83,020	D	85,310	B	88,275	A	96,840

One advantage of the physico-chemical AWT method is its adaptability to stage construction of the various modular components (see Figure V-1). Based on removal requirements as established for BOD, phosphorus and nitrogen (Tables VI-1, VI-2, and VI-6), the coagulation-sedimentation and ammonia stripping modular units will be needed for Plans A and B for the 1970-1980 design period. In these plans, for the period 1980 to 2000, rapid sand filtration and grandular carbon adsorption will be required to meet water quality objectives. For Plans C and D, the first three modular units will be needed for the design period 1970-1980, with the fourth unit, grandular carbon adsorptive, required for the years 1980 to 2000. Table VII-2 is a cost comparison of all alternatives indicating the modular unit staging required for the various design periods.

Table VII-2

COST SUMMARY OF ALTERNATIVE PLANS

		Design Period				
		1970-1980		1980-2000		
Plan	Secondary System and Interceptor Cost ($1,000)	Required AWT Modular Units[1]	Cost ($1000)	Required AWT Modular Units[1]	Cost ($1000)	Present Worth Cost ($1000)
A	36,985	1, 2	7,870	1, 2, 3, 4	34,495	79,350
B	38,595	1, 2	7,180	1, 2, 3, 4	28,760	74,535
C	41,975	1, 2, 3	14,333	1, 2, 3, 4	18,990	75,298
D	49,475	1, 2, 3	9,160	1, 2, 3, 4	20,385	79,020
D*	37,990	1, 2, 3	9,160	1, 2, 3, 4	20,385	67,535

[1] AWT Modular Units

1. Coagulation-sedimentation
2. Ammonia stripping
3. Rapid sand filtration
4. Grandular carbon adsorption

Although Plan D* appears to be the most economic alternative for meeting long-range water quality objectives in the Basin, there are certain inherent disadvantages to adopting this system. These disadvantages are discussed later in this chapter. Plan B is the second least costly alternative.

2. Tangible and Intangible Considerations

The long-range goal of the water quality management program for the Patuxent Basin is to provide water of a quality and quantity consistent with proposed uses. Many of the proposed uses have both tangible and intangible benefits.

The modular treatment sequence provides a series of steps toward complete renovation of wastewater for reuse. While the renovation of wastewater for deliberate municipal re-cycling may not be essential in the near future in the Patuxent Basin, the renovation for recreational use and fish propagation is imminent.

Greater use of the waters of the Basin for municipal and industrial needs could be realized if the organic and inorganic impurities were removed. Water of potable quality could be obtained by application of advanced wastewater treatment methods and aided utilization of the assimilative capacity of the river.

The financial benefits of providing optimal water quality for all projected uses of the Basin waters have not been determined. Many of the potential recreational and commercial uses have not been fully developed or explored. The current uses and financial values of the water and land related uses of resources of the Basin are given in Table II-3.

The estuary and upper reaches of the river are a very valuable resource in terms of both commercial and sport fishing and recreation (Table II-3).

It has been estimated that the Patuxent Estuary is capable of producing oysters having an annual dockside value of over $17 million. Assuming that in the next decade during which the population will increase twofold, the recreational uses double, and the oyster production reaches one-fourth of its potential, the value of water and land related resources could be over $15 million per year.

If Plan B or C were selected and using a 30-year amortization period, the annual cost of providing wastewater treatment in the Basin would be $4,600,000 per year. Using the above assumptions and excluding benefits for water supply, the maintenance of good water quality in the Patuxent Basin could have a benefit/cost ratio of about 3.2. Plan A would have a benefit/cost ratio of less than 3.0.

Many aspects of maintaining good water quality provide intangible benefits. In Table VII-3 is a subjective evaluation of these intangible benefits for the five alternative plans for water quality management in the Basin. Based on this evaluation, it appears that Plans A, B, and C, will have similar total secondary intangible benefits. Plan B, which has the highest ranking, appears to be the most desirable in terms of intangible benefits.

Based on both tangible and intangible water quality and quantity aspects and benefits, Plan B appears to be most advantageous. The plan also allows for engineering and technical flexibility which will be discussed later in this Chapter.

3. Institutional Arrangement Considerations

The need and complexity of institutional arrangements depend principally on which plan is adopted for water quality management in the Basin.

Table VII-3

SUBJECTIVE EVALUATION OF WATER QUALITY MANAGEMENT ALTERNATIVES

Water Quality and Quantity Aspect (Secondary Effects**)	Alternative Plans A	B	C	D	D*
Aesthetic improvement in the water quality of Middle Reach	2	3	3	4	4
Increase in natural stream flow of the Middle Reach	4	4	3	-	-
Increase in natural flow to the estuary	4	4	4	4	4
Reduction in number of stream miles subject to malfunctions in treatment facilities	1	2	3	3	3
Increased protection of shellfish area of Patuxent Estuary	3	3	2	-	-
Total	14	16	15	11	11

* Denotes abandoning existing secondary systems and constructing a single secondary plant near Western Branch to treat all wastewater of the upper basin.

** Effects incidental to principal objective of maintaining 5.0 mg/1 DO, with the following definition of ratings:

- Negative effect
1 No effect
2 Slight positive effect
3 Significant
4 Very significant effect
? Unknown effect

For example, if Plan A is selected, the existing authority invested in MSDH, MDWR, and the counties would be adequate. If Plan B, C, or D is selected, a considerable cost saving can be realized. However, the selection would require cooperative efforts and actions.

Either the State of Maryland working through the Patuxent Basin Sanitary Advisory Committee or the Waste Acceptance Service Program as discussed in Chapter V could be utilized in the planning and implementation phase of the comprehensive program.

4. Engineering and Technical Feasibility

The major advantage of the modular sequence of advanced waste treatment is in the adaptability of the system. Units can be readily added or deleted according to the response of the river and estuarine systems to wastewater effluents. If less costly or more efficient methods are developed, they also can be readily incorporated.

The ability to maintain this adaptability in a given system is an important factor in selecting a plan for secondary and advanced wastewater treatment. While Plan D* would be the least costly according to current estimates of treatment cost and technology, the large initial investments in interceptors may not be economically justified if the cost of AWT is subsequently reduced drastically. This plan would not utilize the natural assimilative capacity of the Patuxent River and because of the waste transport via interceptors there would be a significant loss of flow from the upper portion of the Basin. Also, since the entire waste load of the basin would be treated at one point, any malfunction in the treatment procedures would have a extreme effect on the lower estuary.

B. REVIEW OF ALTERNATIVE PLANS

A compendium of the various alternatives was made using the following:

1. Cost of wastewater treatment and interceptors,
2. Tangible and intangible benefits,
3. Institutional arrangements and cooperative action,
4. AWT adaptability, and
5. Flexibility of consolidating secondary treatment systems (Table VII-5).

Table VII-4

COMPENDIUM OF VARIOUS ALTERNATIVES

Plan	Advantages	Disadvantages
A	1. Low initial cost	1. High long-range cost
	2. No interceptors required	2. No flexibility in consolidating secondary systems
	3. Little need for cooperative action	
	4. Fair subjective evaluation	
	5. Very good AWT adaptability	
B	1. Low initial cost	1. Some need for cooperative action
	2. Fairly low long-range cost	2. Short length interceptors
	3. Highest subjective evaluation	
	4. Good AWT adaptability	
	5. Very good flexibility in consolidating secondary systems	

Table VII-4 (Continued)

Plan	Advantages	Disadvantages
C	1. Fairly low initial cost	1. Fairly high long-range cost
	2. High subjective evaluation	2. Requires considerable co-operative action
	3. Good AWT adaptability	3. Long length interceptors needed
	4. Good flexilility in consolidating secondary systems	
D	1. Fair AWT adaptability	1. High initial cost
	2. Some flexibility in consolidating secondary systems	2. High long-range cost
		3. Very long length interceptors needed
		4. Low subjective evaluation
		5. Requires considerable co-operative action
D*	1. Low initial cost	1. Very long interceptors needed
	2. Low long-range cost	2. Low subjective evaluation
	3. Fair AWT adaptability	3. Requires considerable co-operative action
		4. Large initial investment
		5. Loss of stream flow in the Upper Basin

* Denotes consolidation of secondary treatment systems to a single plant near Western Branch.

From the preceding compendium, it appears that Plan B is the most advantageous. A summary of the plan is given below:

Table VII-5

PLAN B

	Design Volumes and AWT Units				
AWT Systems	1970 - 1980 Units*	1970 - 1980 mgd	1980 - 2000 Units*	1980 - 2000 mgd	Secondary Systems
Laurel Parkway	1, 2	9.0	1,2,3,4,	13.0	Laurel Parkway Maryland City (Md. House of Correction)
Savage	1, 2	8.0	1,2,3,4	15.0	Savage
Bowie-Belair	1, 2	14.0	1,2,3,4	20.0	Patuxent Ft. G.G. Meade #2 Ft. G.G. Meade #1 Bowie-Belair Bowie-Horsepen
Western Branch	1, 2	8.0	1,2,3,4	16.0	Western Branch (Marlboro Meadows) (Rural Anne Arundel)

* Notation for AWT Units:

1. Coagulation-sedimentation
2. Ammonia stripping
3. Rapid sand filtration
4. Granular carbon adsorption

BIBLIOGRAPHY

1. Governor's Patuxent River Advisory Committee, "The Patuxent River, Maryland's Asset-Maryland's Responsibility," July 1968.
2. Public Law 84-660, (33 U.S.C. 466 et.seq.), Federal Water Pollution Act.
3. Crooks, J.W. and O'Bryan, D., "Water Resources of the Patuxent River Basin, Maryland," U.S. Geological Survey, Atlas #A-244, Washington, D.C., 1967.
4. Elser, H.J., "Patuxent River Creek Census - 1963," National Resources Institute, University of Maryland, Ref. No. 63-65.
5. Sheare, L.W., Ritcher, D.E., Jr., and Frisbir, C.M., "Sport Fishing Survey in 1960, Lower Patuxent Estuary," Chesapeake Science Vol. 3, No. 1.
6. Allison, James T., "The Patuxent River - Physical, Chemical and Bacteriological Water Quality Report," Maryland Department of Water Resources, January 1967.
7. Allison, James T. (as above) No. 2, unpublished
8. Allison, James T. (as above) No. 3, unpublished
9. Allison, James T. (as above) No. 4, Maryland Department of Water Resources
10. Jaworski, N.A., "Optimal Release Sequence for Water Quality Control in Multiple Reservoir Systems," CB-SRBP Technical Paper No. 13, FWPCA, Charlottesville, Virginia, 1968.
11. Hall, C., "Patuxent Estuary Survey," MDWR 1968, unpublished.
12. Jaworski, N.A., "Potomac Estuary Nutrient Study," CTSL, MAR, FWPCA, 1969, unpublished.

13. Torpey, W.N., "Effects of Reducing Pollution of Thames Estuary," Water and Sewage Works, July 1968.

14. LaBuy, J.L., "Biological Survey of the Upper and Middle Patuxent River and Some of Its Tributaries," CB-SRBP Working Document No. 29, MAR, FWPCA, Charlottesville, Virginia, June 1968.

15. Mihursky, J.A., "Patuxent Thermal Studies," Natural Resources Institute Special Report No. 1, University of Maryland, January 1969.

16. Cory, R.L., "Epifauna of the Patuxent River Estuary for 1963 and 1964 Chesapeake Science," Vol. 8, No. 2, June 1967.

17. Heidel, S.G. and Fremer, W.W., "Chemical Quality of Water and Trace Elements in the Patuxent River Basin," Maryland Geological Survey Report of Investigations No. 1, 1965.

18. Cory, R.L. and Nauman, J.W., "Temperature and Water Quality Conditions of the Patuxent River Estuary, 1966 through 1967," U.S. Geological Survey, Open File.

19. Mihursky, J.A., "Patuxent River Estuary Study," NRI Ref. No. 63-66, University of Maryland, 1963.

20. Mihursky, J.A., "Summary Report on Tidal Conditions of the Tidal Patuxent River," NRI Ref. No. 68-7, University of Maryland, 1968.

21. Annotated Code of the Laws of Maryland.

22. Mihursky, J.A.; Stross, R.G.; Kennedy, V.S.; Heink, D.R.; Morgan, R.P., "Effects of Thermal Pollution on Productibity and Stability of Estuarine Communities," Third annual report, Water Resources Research Center, University of Maryland, 1967.

23. Nash, C.B., "Environmental Characteristics of a River Estuary," Maryland Department Resources and Ed. (64); 147-174, 1947.

24. Mihursky, J.A., "Patuxent Thermal Study - Progress Report," NRI Ref. No. 66-47, University of Maryland, September 1966.

25. Beavin, G.F., "Temperature and Salinity of Surface Water at Solomons, Maryland," Chesapeake Science 1(1):2-11, 1960.

26. Wolman, A.; Geyer, J.C.; and Beavin, B.E., "Patuxent Regional Sewerage Report," Board of Consultants, Baltimore, Maryland, 1961.

27. Whitman, Requardt and Accociates, "Howard County Sewerage Report," Howard County Metropolitan Commission, June 1958.

28. Whitman, Requardt and Associates, "Water and Sewerage Master Plan Report, Anne Arundel County," Office of Planning and Zoning, 1967.

29. State of Maryland Water Resources Regulation 4.8, Maryland Water Resources Commission, May 22, 1967.

30. Soil Conservation Service, USDA, "Little and Middle Patuxent Preliminary Investigation" under PL 566, College Park, Maryland, September 1968.

31. Smith, C.E. and Chapman, R.L. "Recovery of Coagulant, Nitrogen Removal and Carbon Regeneration in Wastewater Reclamation," South Tahoe Public Utility District, South Lake Tahoe, Cal., June 1967.

32. Trident Engineering Associates, "Feasibility Study on a Waste Acceptance Service Program for the State of Maryland," Vol. II, Contract No. 095-338, Maryland State Department of Health, January 1968.

33. Pritchard, D.W., "Fisheries vs. the Exploitation of the Nonextractive Resources in Estuaries," supplement to Transactions, Marine Technology Society Conference, June 27-29, 1966.

34. Bishop, D.L., "Status and Outlook for Phosphorus Removal from Wastewaters," FWPCA, Cincinnati, Ohio, September 1967.

35. Barth, E.F. and Ettinger, M.B., "Mineral Controlled Phosphorus Removal in the Activated Sludge Process," Journal Water Pollution Control Federation, Vol. 39, August 1967.

36. Eberhardt, W.A. and Nesbitt, J.B., "Chemical Precipitation of Phosphorus in a High Rate Activated Sludge System," Journal Water Pollution Control Federation, Vol. 40, July 1968.

37. Culp, R.L., "Wastewater Reclamation by Tertiary Treatment," Journal Water Pollution Control Federation, Vol, 35, June 1963.

38. Inter-Departmental Task Force on Project Potomac, "Sub-Task Force on Water Quality, Final Report," in publication.

39. Machkenthun, K.M., "A Review of Algae, Lake Weeds and Nutrients," Journal Water Pollution Control Federation, October 1962.

40. Sawyer, C.N., "Some New Aspects of Phosphates in Addition to Lake Fertilization," Sewage and Industrial Wastes, Vol. 24, No. 6, 1952.

41, Chu, S.P., "The Influence of Mineral Composition of the Medium on the Growth of Planktonic Algae," Journal of Ecology, Vol, 31, No. 2, 1943.

42. Jaworski, N.A.; Donovan, G. and Villa, O., "Nutrients in the Upper Potomac River Basin, 1966" (in preparation by CTSL).

UNREGULATED MEAN MONTHLY, and DESIGN FLOWS

PATUXENT RIVER BASIN

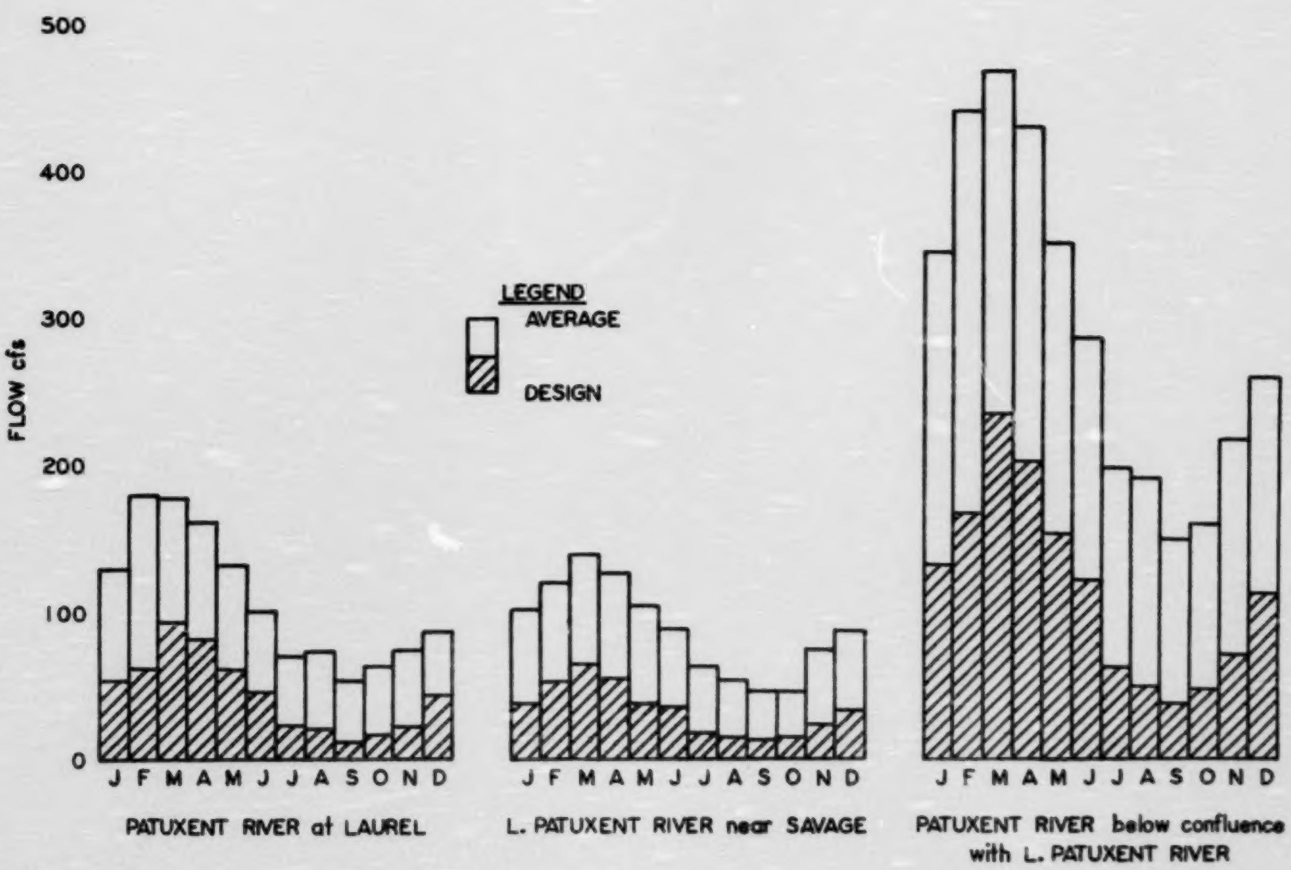


FIGURE A-1

ANNUAL FLOW DURATION CURVE
PATUXENT RIVER BASIN
LAUREL
(BURTONSVILLE)
1914-1944

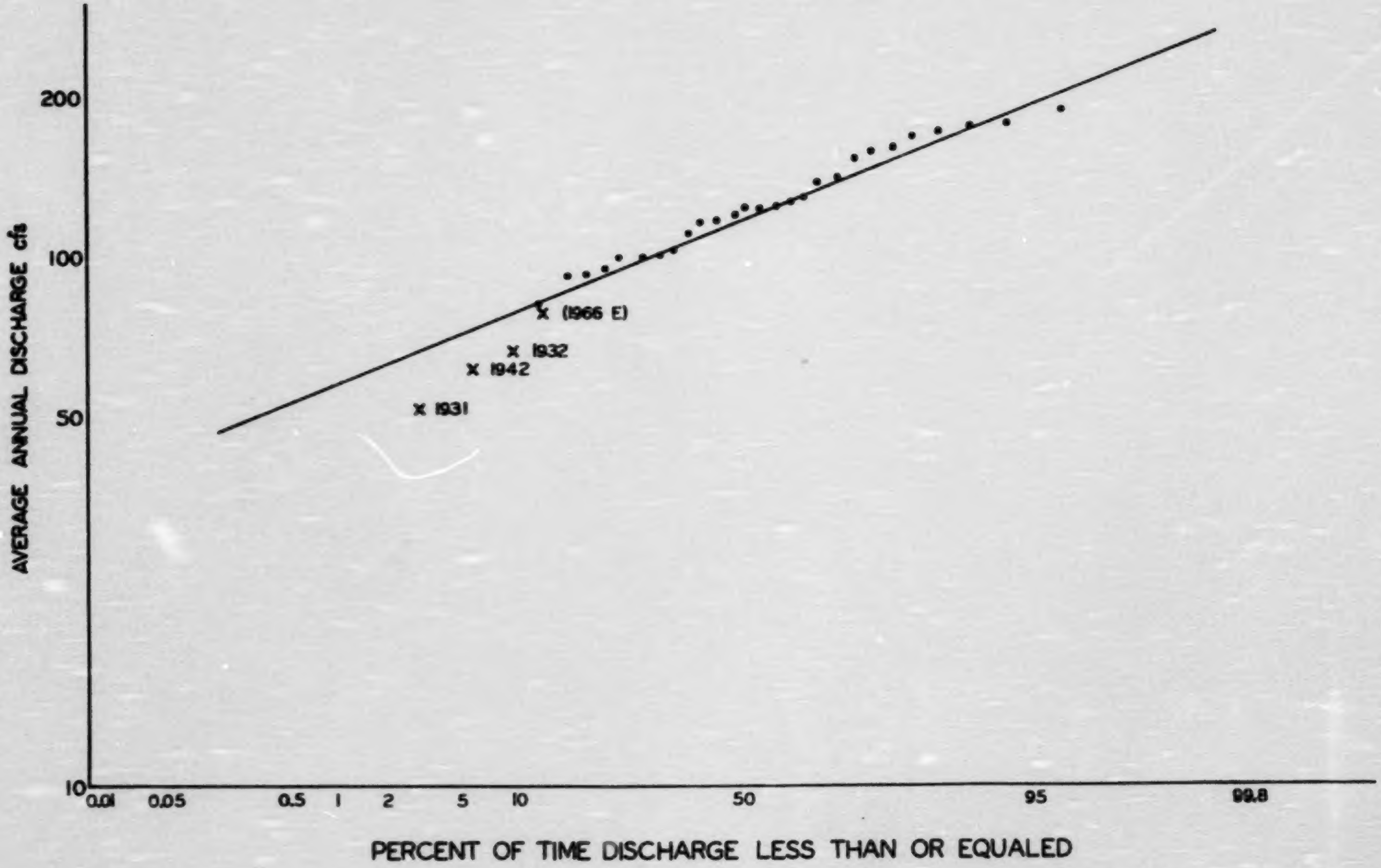
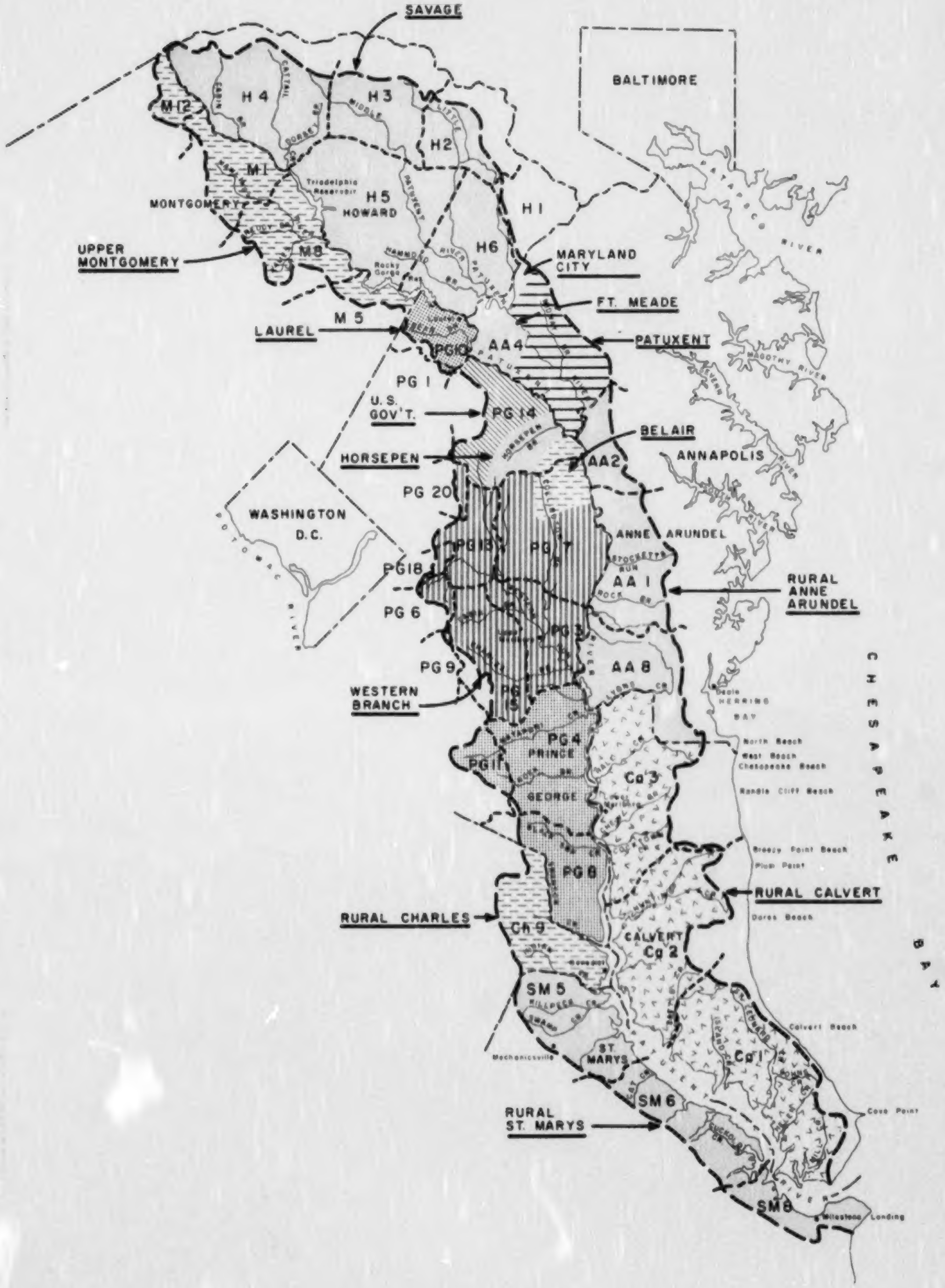
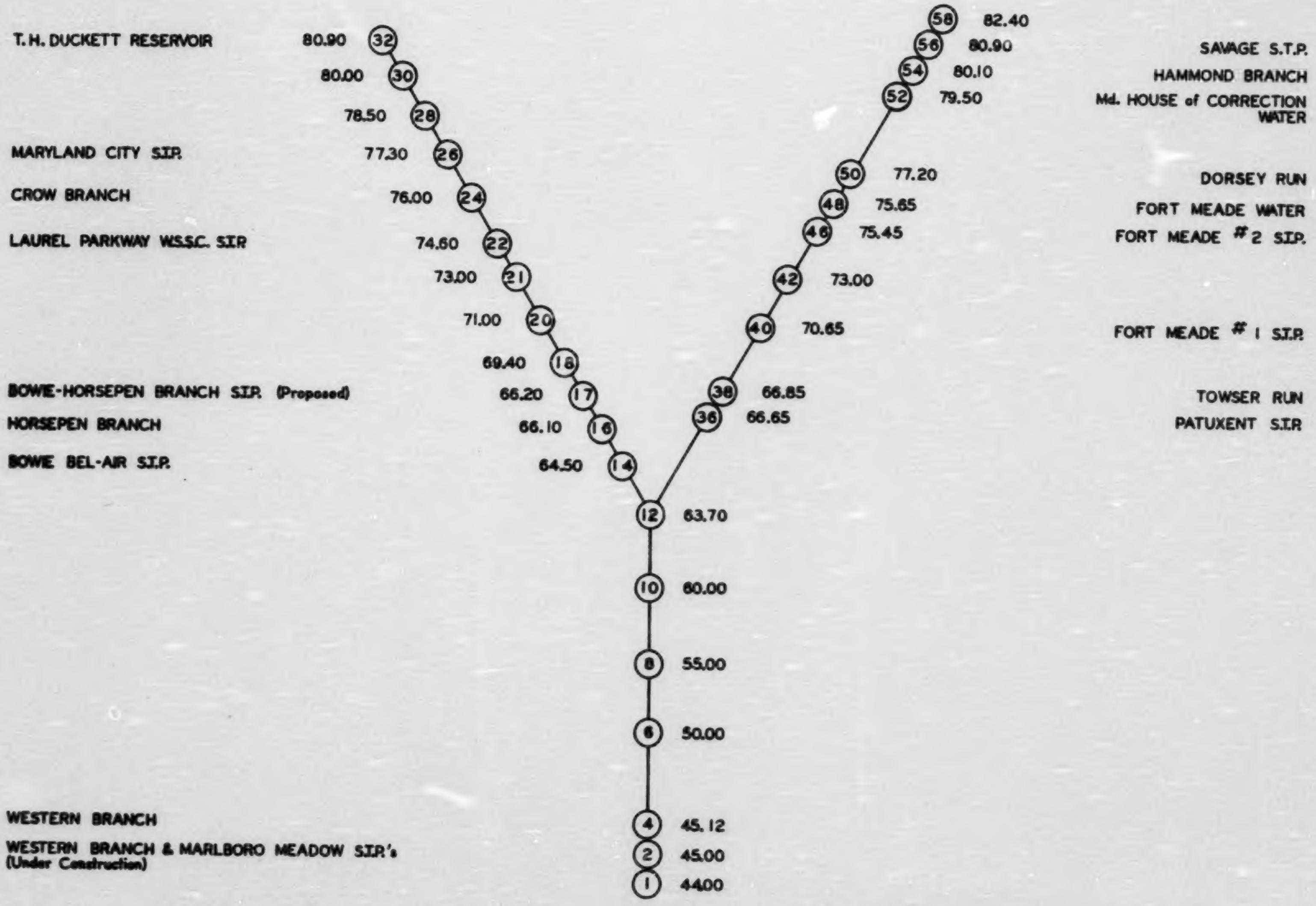


FIGURE A-2


SAVAGE
BALTIMORE
M12
H4
H3
H2
M1
H5
HOWARD
Triadelphia Reservoir
MONTGOMERY
H1
H6
UPPER MONTGOMERY
M8
Rocky Gorge
MARYLAND CITY
FT. MEADE
LAUREL
M 5
PG10
AA4
PATUXENT
PATAPSCO RIVER
MAGOTHY RIVER
PG 1
U. S. GOV'T.
PG 14
BELAIR
HORSEPEN
AA2
ANNAPOLIS
PG 20
WASHINGTON D.C.
POTOMAC RIVER
PG13
PG 7
ANNE ARUNDEL
PG18
AA 1
RURAL ANNE ARUNDEL
PG 6
PG 3
AA 8
PG 9
WESTERN BRANCH
PG 5
HERRING BAY
CHESAPEAKE BAY
North Beach
Chesapeake Beach
Randle Cliff Beach
PG 4
PRINCE
PG11
GEORGE
Ca 3
Breezy Point Beach
Plum Point
PG 8
RURAL CALVERT
Dares Beach
RURAL CHARLES
Ch 9
CALVERT
Ca 2
SM 5
Calvert Beach
Mechanicsville
ST. MARYS
Ca 1
SM 6
RURAL ST. MARYS
Cove Point
SM 8
Millstone Landing

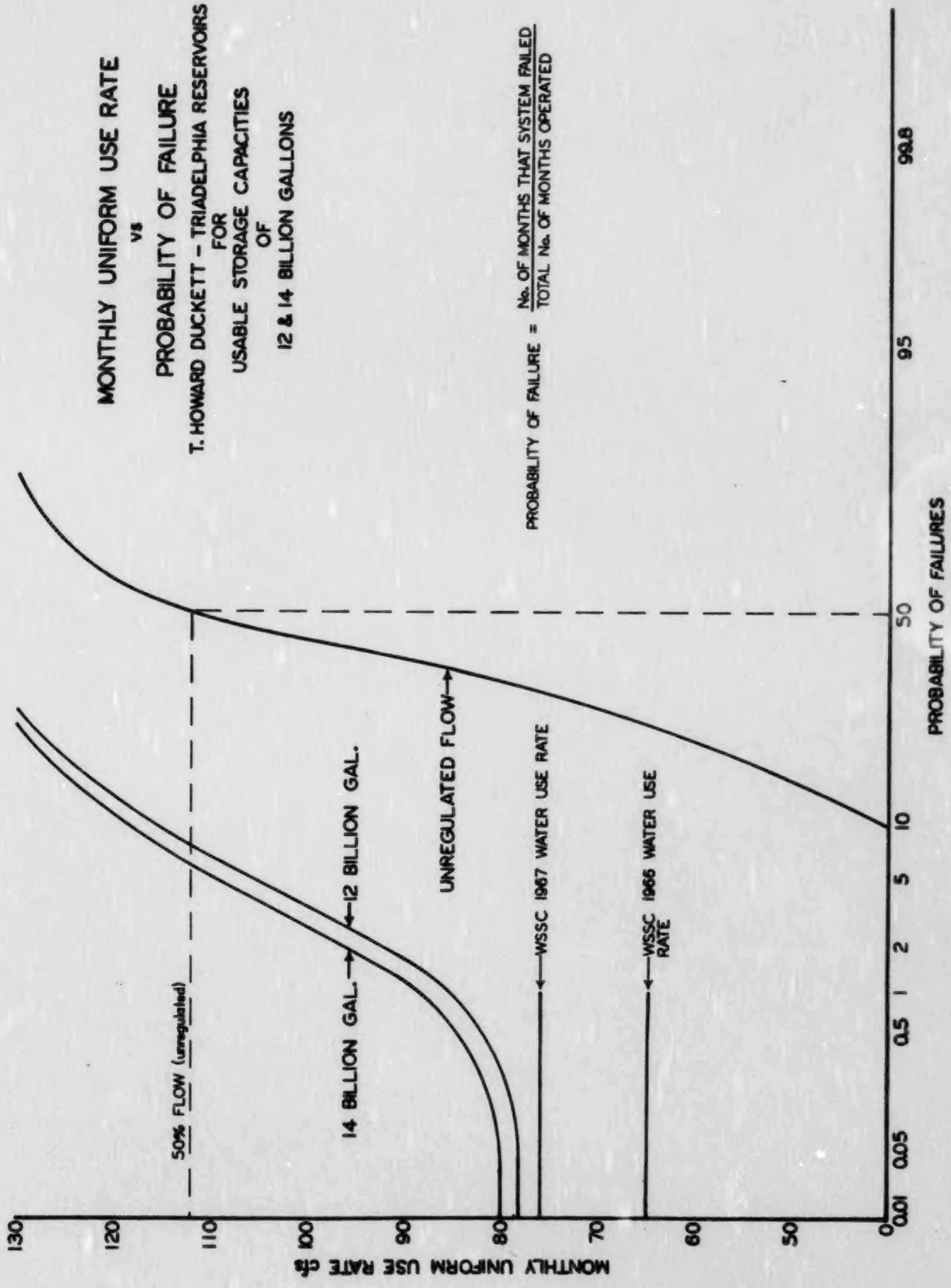
PATUXENT RIVER BASIN

FIGURE A-3


T. H. DUCKETT RESERVOIR
80.90
32
80.00
30
78.50
28
MARYLAND CITY S.T.P.
77.30
26
CROW BRANCH
76.00
24
LAUREL PARKWAY W.S.S.C. S.T.P.
74.60
22
73.00
21
71.00
20
69.40
18
BOWIE-HORSEPEN BRANCH S.T.P. (Proposed)
66.20
17
HORSEPEN BRANCH
66.10
16
BOWIE BEL-AIR S.T.P.
64.50
14
58
82.40
SAVAGE S.T.P.
56
80.90
HAMMOND BRANCH
54
80.10
Md. HOUSE of CORRECTION WATER
52
79.50
50
77.20
DORSEY RUN
48
75.65
FORT MEADE WATER
46
75.45
FORT MEADE #2 S.T.P.
42
73.00
40
70.65
FORT MEADE # 1 S.T.P.
38
66.85
TOWSER RUN
36
66.65
PATUXENT S.T.P.
12
63.70
10
60.00
8
55.00
6
50.00
WESTERN BRANCH
4
45.12
WESTERN BRANCH & MARLBORO MEADOW S.T.P.'s (Under Construction)
2
45.00
1
44.00

SCHEMATIC of MATHEMATICAL MODEL of PATUXENT RIVER

FIGURE A-4



MONTHLY UNIFORM USE RATE vs PROBABILITY OF FAILURE
T. HOWARD DUCKETT - TRIADELPHIA RESERVOIRS FOR USABLE STORAGE CAPACITIES OF 12 & 14 BILLION GALLONS

PROBABILITY OF FAILURE = No. OF MONTHS THAT SYSTEM FAILED / TOTAL No. OF MONTHS OPERATED

FIGURE A-5

APPENDIX B

TABLES

Table B-1

PATUXENT RIVER
SURVEY STATION LOCATIONS
Chesapeake Field Station

Station Number	Location	River Mile
5	Maryland Rt. 4 Bridge	47.45
6	Queen Anne's Bridge	54.88
7	Maryland Rt. 214 Bridge	56.00
8	John Hanson Highway Bridge-U.S. 50 & 301	60.74
9	Defense Highway Bridge on Maryland Rt. 3	63.67
10	Patuxent River just upstream from Little Patuxent-Priest Bridge	64.00
11	Bridge behind Bowie Race Track	66.37
12	Pennsylvania Railroad Bridge crossing Patuxent off of Lemon Bridge Road	68.65
12A	Road off of Jericho Road by Mark F. Arban & Co. through gravel pit area to river approximately 0.3 miles upstream from Lemons Bridge (Marked)	69.35
12B	Kluckhuhn Loop Road approaches close to river ½ mile downstream from Duvall Bridge	70.95
13	Duvall Bridge on Patuxent Wildlife Refuge	71.50
13A	Off of River Road on Refuge just upstream from Beach Island (Marked)	72.65
13B	Off of River Road on Refuge 0.84 miles upstream from Station 13A (Marked)	73.40
14	Baltimore-Washington Expressway Bridge on Patuxent	75.00
14A	Brock Bridge on Patuxent on Brock Bridge Road	75.60
15	Maryland Route 198 Bridge on Patuxent River	78.02

Table B-1 (Continued)

Station Number	Location	River Mile
L1	Little Patuxent River just upstream from confluence with Patuxent River	63.80
L2	Maryland Rt. 424 Bridge	66.80
L2A	Towser Run at Evergreen Road	-
L3	Bridge immediately upstream from Woodwardville	70.70
L4	Old Forge Bridge	74.05
L5	Simmon's Bridge on Rt. 198	75.50
L6	Baltimore-Washington Expressway Bridge	77.25
L6A	Dorsey Run at Maryland Rt. 32	-
L7A	Brock Bridge Road crossing the Little Patuxent River	79.84
L7	Bridge on U.S. Rt. 1 downstream from Savage	81.48
L7B	Hammond Branch at Coolesville School Road	-
L7A	Hammond Branch at U.S. Rt. 1	-

Table B-2

PATUXENT ESTUARY SURVEY
STATION LOCATIONS
Chesapeake Field Station

Station Number	Location	River Mile
E1	Rt. 50 Bridge	60.74
E2	Queen Anne's Bridge	54.88
E3	Bell's Junk Yard	52.50
E4	Trailer Court	48.60
E5	Wayson's Corner, Rt. 4 Bridge	47.45
E6	Mouth of Western Branch	45.20
E7	Mouth of Lyon's Creek	41.75
E8	Nottingham	38.40
E9	Lower Marlboro, opposite wharf	32.20
E10	High power lines	31.90
E11	One-half way between Trueman Pt. and Deep Landing	28.50
E12	500 yds. east of PEPCO Canal	27.30
E13	Chalk Point	25.00
E14	Benedict Bridge Channel	22.90
E15	Buoy 21 - Sheridan Pt.	19.40

Table B-3

Unregulated Mean Monthly and Design Flows*

For USGS Gaging Station, Patuxent River Basin

	Little Patuxent at Guilford (34 sq.miles)		Little Patuxent at Savage (98.4 sq.miles)		Dorsey Run near Jessup (11.6 sq.miles)		Patuxent Near Unity (34.8 sq.miles)		Patuxent Near Laurel** (133 sq.miles)		Western Branch near Largo (30.8 sq.miles)	
Month	Mean	Design	Mean	Design	Mean	Design	Mean	Design	Mean	Design	Mean	Design
January	43	16	103	37	12.5	3.5	3	12.5	130	54	28.0	8.9
February	53	25	120	51	19.5	10.0	47	22.0	180	63	41.0	16.8
March	60	32	140	65	27.5	12.5	54	28.0	177	95	53.0	26.0
April	54	21	128	55	18.5	6.5	46	19.0	162	82	43.0	15.7
May	39	18	105	39	11.7	3.5	38	15.5	132	64	24.0	6.1
June	28	14	88	35	9.4	2.9	28	10.2	104	48	16.0	4.0
July	21	7	63	19	6.4	1.9	20	4.3	70	23	10.0	1.7
August	18	6	54	14	7.6	1.9	13	5.0	76	19	12.0	1.0
September	17	4.6	47	12	6.4	2.0	15	5.1	54	13	9.2	1.0
October	20	7.0	46	15	6.9	1.9	13	5.8	62	17	9.0	2.6
November	28	10.0	74	25	9.7	2.5	23	9.8	72	22	19.0	6.2
December	34	14.0	88	33	18.0	4.0	30	10.2	88	43	24.0	8.0
Mean	34		88		12.8		27		108		24.0	
7-day 10-year	4.4		12.0		1.9		4.1		9.2		1.3	

* Design flow is such a mean monthly low flow value in cfs, based on a log normal probability distribution which occurs five percent or less of the time.

** Does not include regulated flow values (Formerly Burtonsville).

Table B-4

Calculated Mean Monthly and Design Flow**
for Selected Sampling Stations

Month	Patuxent at** Station 10 (181 sq.miles)		Little Patuxent Station L1 (161 sq.miles).		Patuxent at** Station 9 (342 sq.miles)		Patuxent at** Station 5 (410 sq.miles)		Patuxent below** Western Br. (525 sq.miles)	
	Mean	Design	Mean	Design	Mean	Design	Mean	Design	Mean	Design
January	176	73	169	61	345	133	414	159	515	191
February	244	85	197	83	441	168	529	201	677	262
March	240	129	238	106	469	235	562	282	754	376
April	220	111	210	90	430	201	516	241	671	298
May	180	87	172	64	352	151	422	181	509	203
June	141	68	144	57	284	122	340	146	398	160
July	95	31	103	31	198	62	237	74	273	80
August	103	26	88	24	191	50	229	60	272	63
September	73	18	77	20	150	38	180	45	213	49
October	84	23	75	24	160	48	192	57	224	67
November	98	30	121	41	217	71	260	85	329	107
December	120	58	144	54	260	112	312	134	398	163
Mean	147		144		291		349		436	
7-day 10-year	12.6		19.6		32.2		38.8		43.5	

* Design flow is such a mean monthly low flow value in cfs, based on a log normal probability distribution which occurs five percent or less of the time.

** Does not include regulated flow value (Formerly Burtonsville).

Table B-5

OYSTERS, SOFTSHELL CLAMS, AND CRABS HARVESTED BY COUNTY

BUSHELS OF OYSTERS HARVESTED

Year	St.Marys Co.	Calvert Co.	Charles Co.	Total	Dockside Dollar Value 1/
1963-64	14,500	27,700	900	43,100	$172,400
1964-65	17,700	22,500	1,900	42,100	168,400
1965-66	41,200	18,800	5,900	65,900	263,600
1966-67	40,500	33,300	2,300	76,100	304,400

BUSHELS OF SOFTSHELL CLAMS HARVESTED

Year	Calvert Co.	St.Marys Co.	Total	Dockside Dollar Value 2/
1964-65	9,600	600	10,200	$25,500
1965-66	7,000	--	7,000	17,500
1966-67	2,300	--	2,300	5,750

POUNDS OF CRABS HARVESTED

Year	St.Marys Co.		Calvert Co.		Charles Co.		Total	Dockside Dollar Value 3/
	Hard	Soft & Peeler	Hard	Soft & Peeler	Hard	Soft & Peeler		
1963	155,000	6,000	13,500	2,200	7,500	600	252,300	$18,400
1964	180,000	8,400	131,600	3,200	65,000	1,200	389,400	31,100
1965	420,000	13,000	115,200	20,000	130,000	1,300	699,500	48,000

1/ Based on $4/bushel

2/ Based on $2.50/bushel

3/ Based on 8¢/pound

Table B-6

WASTEWATER SERVICE AREA POPULATION PROJECTIONS
PATUXENT RIVER BASIN

County	Percent of 1960's Population in Basin	Percent of Drainage Area in Basin	Wastewater Service Areas	Population Projections 1980	Population Projections 2000	Population Projections 2020
Prince Georges (Revised)	18	50	Total	770,300	1,002,600	1,305,000
			Laurel	49,000	75,000	100,000
			U.S. Government land	5,900	7,900	10,500
			Horsepen	20,000	33,000	56,000
			Belair	31,000	45,000	60,000
			Western Branch	62,000	137,000	289,000
			Rural Prince Georges	7,700	10,000	13,000
Montgomery	2	10	Total	630,200	870,000	1,300,000
			Upper Montgomery	*	*	*
Anne Arundel	11	31	Total	415,700	600,000	864,000
			Maryland City	15,000	20,000	27,000
			Ft. Meade	51,000	63,000	75,000
			Patuxent	30,000	40,000	54,000
			Rural Anne Arundel	7,100	17,700	44,000
Howard	62	77	Total	112,800	215,000	413,000
			Savage	73,000	157,000	316,000

---

* Most of this area is served by the waste treatment facilities of Washington, D.C.

Table B-6 (Continued)

County	Percent of 1960's Population in Basin	Percent of Drainage Area in Basin	Wastewater Service Areas	Population Projections		
				1980	2000	2020
Calvert	39	83	Total	26,200	46,200	81,500
			Rural Calvert	10,500	18,500	32,600
St. Marys	21	24	Total	60,600	72,000	85,300
			Rural St. Marys	35,000	42,000	50,000
Charles	6	6	Total	58,200	75,300	97,400
			Rural Charles	2,800	3,300	4,000

Table B-7

WASTE LOADING PROJECTIONS AND DISTRIBUTIONS FOR MAJOR WASTEWATER SERVICE AREAS 1967 AND 1980

Wastewater Service Area	Averages for 1967			1980 Projections				
	Population Served	Flow (mgd)	BOD* (lb/day)	Population Served	Flow (gcpd)	Flow (mgd)	BOD* (pcpd)	BOD* (lb/day)
Maryland City	5,000	0.410	715	12,500	100	1.3	0.15	1,900
Laurel Parkway	21,000	2.600	2,860	49,000	130	6.4	0.17	8,350
Bowie-Horsepen and U.S. Government Land	NS	NS**	NS	26,000	80	2.1	0.15	3,900
Bowie-Belair	23,000	1.900	2,930	31,000	110	3.4	0.15	4,650
Savage	1,500	0.113	320	73,000	100	7.3	0.15	10,900
Md. House of Correction	2,500	0.600	1,780	2,500	--	0.6	--	1,800
Fort Meade #2	16,000	1.000	2,300	22,000	--	1.4	--	3,200
Fort Meade #1	21,000	1.300	2,100	29,000	--	1.8	--	2,900
Patuxent	4,400	0.700	1,085	30,000	150	4.5	0.22	6,600
Rural Anne Arundel County	1,500	0.120	200	7,100	100	0.7	0.15	1,200

* Before treatment

** No major sewage treatment facilities

Table B-7 (Continued)

Wastewater Service Area	Averages for 1967			1980 Projections				
	Population Served	Flow (mgd)	BOD* (lb/day)	Population Served	Flow		BOD*	
					(gcpd)	(mgd)	(pcpd)	(lb/day)
Western Branch Marlboro Meadows	4,000	0.500	600	62,000	100	6.2	0.17	10,500
Rural Prince Georges County	NS	NS	NS	7,700	100	0.8	0.15	1,160
Rural Calvert County	NS	NS	NS	10,500	100	1.1	0.15	1,580
Rural Charles County	NS	NS	NS	2,800	100	0.3	0.15	420
St. Marys County	18,000	1.500	2,500	35.000	100	3.5	0.15	5,250
Total	117,900	10.743	17,390	400,100	--	41.4	--	64,310

* Before treatment

Table B-7 (Continued)

LOADING PROJECTIONS AND DISTRIBUTIONS FOR MAJOR WASTEWATER SERVICE AREAS 2000 AND 2020

Wastewater Service Area	2000			2020		
	Population Served	Flow (mgd)	BOD (lb/day)	Population Served	Flow (mgd)	BOD (lb/day)
Maryland City	17,500	1.8	2,600	24,500	2.5	3,700
Laurel Parkway	75,000	9.7	12,700	100,000	13.0	17,000
Bowie-Horsepen and U.S. Government Land	40,900	4.1	6,150	66,500	6.7	10,000
Bowie-Belair	45,000	5.0	6,800	60,000	6.6	9,000
Savage	157,000	15.0	20,600	316,000	31.6	47,500
Md. House of Correction	2,500	0.6	1,800	2,500	0.6	1,800
Ft. Meade #2	28,000	1.8	3,900	34,000	2.2	3,500
Ft. Meade #1	35,000	2.2	3,500	41,000	2.6	4,100
Patuxent	40,000	6.0	8,900	54,000	8.1	11,800
Rural Anne Arundel County	17,700	1.8	2,700	44,000	4.4	6,600
Western Branch Marlboro Meadows	137,000	13.7	20,600	289,000	28.9	48,800
Rural Prince Georges County	10,000	1.0	1,500	13,000	1.3	1,950
Rural Calvert County	18,500	1.1	2,870	32,600	3.2	4,800

Table B-7 (Continued)

Wastewater Service Area	2000			2020		
	Population Served	Flow (mgd)	BOD (lb/day)	Population Served	Flow (mgd)	BOD (lb/day)
Rural Charles County	3,300	0.3	500	4,000	0.4	600
Rural St. Marys County	42,000	4.2	6,300	50,000	5.0	7,500
Total	669,400	68.4	101,420	1,131,100	117.1	178,650

Table B-8

COUNTY POPULATION PROJECTIONS

County	1960	1980	2000	2020
Anne Arundel				
NPA	206,600	400,500	556,200	700,700
MSPD	206,600	415,700	600,000	866,000
Calvert				
NPA	15,800	26,000	42,000	66,000
MSPD	15,800	26,200	46,200	81,500
Charles				
NPA	32,600	52,000	80,000	112,000
MSPD	32,600	58,200	75,300	97,400
Howard				
NPA	36,200	100,000	240,400	450,700
MSPD	36,200	112,800	215,000	413,000
Montgomery				
NPA	340,900	551,000	913,000	1,652,000
MSPD	340,900	630,200	870,000	1,300,000
Prince Georges				
NPA	357,400	745,000	1,188,000	1,568,000
MSPD	357,400	770,300	1,002,600	1,305,000
St. Marys				
NPA	38,900	52,000	83,000	132,000
MSPD	38,900	60,600	72,000	85,500

Table B-9

INVENTORY OF WASTEWATER DISCHARGES WITHIN THE PATUXENT RIVER BASIN

Facility	Employees or Population Served	Waste Type	Design Population	Design Flow (mgd)	Type of Treatment	Receiving Stream	Remarks
WSSC Water Treatment Plant	NA	Silt	NA	NA	Lagoon	Walkers Br.	Filter backwashing
Maryland City STP	5,000	Sanit.	7,500	0.75	Secondary	Patuxent R.	Anne Arundel Co.
M.S.S. Motel, Inc. (Laurel area)	27	Sanit.	NA	NA	NA	Patuxent R.	Trailer Park (Howard Co.)
Mid-way Mobile Home Park (Laurel area)	270	Sanit.	NA	NA	NA	Patuxent R.	Trailer Park (Howard Co.)
Pfister Mobile Home Park (Laurel area)	320	Sanit.	NA	NA	NA	Patuxent R.	Trailer Park (Howard Co.)
Crescent Motel, Inc. (Laurel area)	60	Sanit.	NA	NA	NA	Patuxent R.	Trailer Park (Howard Co.)
Laurel Parkway STP	18,000	Sanit.	24,000	2.400	Secondary	Patuxent R.	Operated by WSSC
Patuxent Wildlife Reserve	170	Sanit.	NA	NA	Tertiary	Patuxent R.	U.S. Govt.
Bowie State Teachers College STP	460	Sanit.	500	0.075	Secondary	Tr.Horsepen Br.	
Bowie Racetrack STP	Varies	Sanit.	NA	NA	Intermed.	Horsepen Br.	
Fairview Trailer Parks (Md.City area)	625	Sanit.	NA	NA	Intermed.	Patuxent R.	Anne Arundel Co.
Bowie-Horsepen Br. STP	0	Sanit.	0	0	-	Patuxent R.	Proposed plant

Table B-9 (Continued)

Facility	Employees or Population Served	Waste Type	Design Population	Design Flow (mgd)	Type of Treatment	Receiving Stream	Remarks
Belair-Bowie STP	23,000	Sanit.	22,000	2.200	Tertiary	Patuxent R.	
Johns Hopkins Applied Physics Lab.	2,000	Ind. & Sanit.	1,600	0.16	Secondery	M.Patuxent R.	In Scaggesville,Md.
W.R. Grace Co.	350	Ind. & Sanit.	600	0.020	Secondary	M.Patuxent R.	In Simpsonville
Folly Quarters Farm	21	Ind. & Sanit.	8,000	-	Secondary	M.Patuxent R.	Owned by U. of Md.
Trans. Gas Co.	30	Sanit.	30	0.030	Secondary	M.Patuxent R.	
KAM Corp.	15	Ind. & Sanit.	15	0.001	Secondary	Plumtree Br.	
Doughoreagan Manor	52	Sanit. & Ind.	NA	NA	Secondary	Tr.L.Patuxent R.	No discharge
Dunloggin STP	600	Sanit.	NA	NA	Secondary	Plumtree Br.	Will discharge to Savage STP
EV-Mar Mobile Home Village (Savage area)	120	Sanit.	NA	NA	NA	L.Patuxent R.	Howard Co.
Savage STP	1,500	Sanit.	10,000	1.0	Secondary	L.Patuxent R.	New plant
Laurel Raceway STP	Varies	Sanit.	7,000	NA	Secondary	Hammond Br.	Operation seasonal
Md.&Va. Mile Producers' Assoc.	45	Sanit. & Ind.	NA	NA	Secondary	Hammond Br.	
Smith's Mobile Home Park (Laurel area)	33	Sanit.	NA	NA	NA	Hammond Br.	Howard Co.

Table B-9 (Continued)

Facility	Employees or Population Served	Waste Type	Design Population	Design Flow (mgd)	Type of Treatment	Receiving Stream	Remarks
S.Regional Detention Center	90	Sanit.	90	0.007	Secondary	Tr.L.Patuxent R.	State of Md.
Holiday Mobile Estates	618	Sanit.	NA	NA	Secondary	Piney Run	Anne Arundel Co.
Md. House of Correction	2,500	Sanit.	NA	0.600	Secondary	Dorsey Run	Included drainage from farm
Ft. Meade STP #2	19,000	Sanit.	15,000	1.500	Secondary	L.Patuxent R.	Included NSA, etc.
Ft. Meade STP #1	16,000	Sanit.	25,000	2.500	Secondary	L.Patuxent R.	
U.S. Naval Acad. Dairy	100	Ind. & Sanit.	NA	NA	Primary	Towers Run	Septic tank - leaching pits
Barton Sand & Gravel	NA	Silt	NA	NA	Lagoon	L.Patuxent R.	
Patuxent STP	4,400	Sanit.	20,000	2.0	Secondary	L.Patuxent R.	Anne Arundel Co.
Baltimore Concrete Plant Co.	NA	Silt	NA	NA	NA	L.Patuxent R.	
Levitt & Sons Sand & Gravel	NA	Silt	NA	NA	Lagoon	L.Patuxent R.	
E.L. Gardner Sand & Gravel	NA	Silt	NA	NA	Lagoon	L.Patuxent R.	
Governor Bridge Tran. site	40	Sanit.	NA	0.015	Secondary	Patuxent R.	Package plant
Davidsonville Nike Site	100	Sanit.	NA	NA	Secondary	Tr.Patuxent R.	

Table B-9 (Continued)

Facility	Employees or Population Served	Waste Type	Design Population	Design Flow (mgd)	Type of Treatment	Receiving Stream	Remarks
Bi-County Aggregate Co.	NA	Silt	NA	NA	Lagoon	Patuxent R.	
Carl Abend Sand & Gravel Co.	NA	Silt	NA	NA	Lagoon	Patuxent R.	
Annapolis Sand & Gravel Co.	NA	Silt	NA	NA	Lagoon	Patuxent R.	
Myer Sand & Gravel Co.	NA	Silt	NA	NA	Lagoon	Patuxent R.	
Andrews AFB STP #3	3,000	Sanit.	6,000	0.48	Secondary	Charles Br.	Trib. of Western Br.
Melwood Mobile Homes	NA	Sanit.	NA	NA	Secondary	Charles Br.	Md.#4 & Dower Hse. Rd.(Prince Georges County)
Upper Marlboro STP	700	Sanit.	600	0.06	Primary	Western Br.	
Prince George's Com. College	NA	Sanit.	1,400	0.028	Secondary	Southwest Br.	Trib. of Western Br.
Marlton Estates	NA	Sanit.	3,000	0.030	Secondary	Charles Br.	Trib. of Western Br.
Western Branch	0	Sanit.	0	0	NA	Western Br.	Proposed 5.0 mgd plant
Northhampton	NA	Sanit.	2,000	0.020	Secondary	Southwest Br.	Trib. of Western Br.
Marlboro Meadows	0	Sanit.	0	0	NA	Patuxent	Proposed 2.0 mgd plant
Mt. Calvert Housing Area	45	Sanit.	NA	NA	Secondary	Tr.Patuxent R.	Operated by U.S. Army

Table B-9 (Continued)

Facility	Employees or Population Served	Waste Type	Design Population	Design Flow (mgd)	Type of Treatment	Receiving Stream	Remarks
Brandywine Housing Area	45	Sanit.	NA	NA	Secondary	Tr.Patuxent R.	Operated by U.S. Air Force
Patuxent Mobile Estates (Lothian area)	450	Sanit.	NA	NA	Secondary	Patuxent R.	Anne Arundel Co.
Wayson's Trailer Pk.	900	Sanit.	NA	NA	Secondary	Patuxent R.	Anne Arundel Co.
Potomac Elec. Corp.	50	Cooling	NA	NA	NA	Patuxent Est.	
Potomac Elec. Corp.	50	Sanit.	100	0.01	Secondary	Patuxent Est.	
Dick Lure's Laundramat	NA	Ind.	NA	NA	NA	Patuxent Est.	
Patuxent Naval Air Station Annex	2,400	Sanit.	NA	NA	Secondary	Patuxent Est.	Calvert Co.
Patuxent Naval Air Station	17,500	Sanit.	15,000	1.5	Primary	Pine Run	Will discharge to County's STP
Patuxent Naval Air Station	150	Sanit.	NA	NA	Secondary	Patuxent Est.	Officers' Club

Table B-10

SUMMARY OF STREAM SURVEY DATA
PATUXENT RIVER BASIN

July 7 - August 11, 1955
Maryland State Health Department

Station Number	Temperature Min. (Deg.C)	Temperature Mean (Deg.C)	Temperature Max. (Deg.C)	BOD Min. (mg/1)	BOD Mean (mg/1)	BOD Max. (mg/1)	DO Min. (mg/1)	DO Mean (mg/1)	DO Max. (mg/1)
7	23.0	24.42	25.5	0.695	1.624	2.5	5.6	6.42	6.9
8	22.5	23.75	25.0	1.7	2.175	2.65	5.9	6.05	6.2
10	20.5	23.3	25.0	0.77	1.178	1.5	5.8	6.32	7.0
14	17.5	19.4	21.0	3.5	4.27	5.25	4.0	4.4	4.7
15A	14.0	18.0	20.5	1.15	2.14	3.25	8.6	9.2	10.0
L2	22.0	24.41	26.0	3.8	4.94	6.35	3.4	4.1	4.7
L3A	22.0	25.0	26.5	2.55	4.87	7.15	2.4	4.5	6.2
L3	21.5	23.75	26.0	1.95	5.175	8.4	7.1	7.15	7.2
L5	21.0	25.67	28.5	1.02	1.53	1.8	6.6	7.25	8.7

Table B-11

SUMMARY OF STREAM SURVEY DATA
PATUXENT RIVER BASIN

March 20-24, 1967
Chesapeake Field Station

Station Number	Temperature Min. (Deg.C)	Temperature Mean (Deg.C)	Temperature Max. (Deg.C)	BOD Min. (mg/1)	BOD Mean (mg/1)	BOD Max. (mg/1)	DO Min. (mg/1)	DO Mean (mg/1)	DO Max. (mg/1)
7	2.5	3.7	5.0	3.2	3.4	3.6	11.2	11.8	12.1
8	2.5	3.4	4.5	0.5	3.6	3.8	6.3	10.5	12.2
9	3.0	3.675	4.5	2.9	3.4	4.1	11.6	11.9	12.2
10	3.0	3.68	5.0	2.0	3.6	4.0	11.5	11.8	12.3
11	3.0	3.64	5.0	2.2	2.4	2.7	11.8	12.0	12.2
12	3.5	4.25	5.0	1.8	2.2	2.8	11.8	11.8	12.4
13	2.5	3.8	5.0	1.5	2.2	3.0	9.9	11.8	12.8
14	3.0	4.1	5.0	1.0	1.9	2.9	10.6	11.7	12.1
15	4.0	4.3	4.5	1.5	2.1	2.9	12.2	12.7	13.6

Table B-11 (Continued)

Station Number	Total Phosphorus as PO_4 Min. (mg/1)	Total Phosphorus as PO_4 Mean (mg/1)	Total Phosphorus as PO_4 Max. (mg/1)	Total Kjeldahl Nitrogen as N Min. (mg/1)	Total Kjeldahl Nitrogen as N Mean (mg/1)	Total Kjeldahl Nitrogen as N Max. (mg/1)	NO_2-NO_3 Nitrogen as N Min. (mg/1)	NO_2-NO_3 Nitrogen as N Mean (mg/1)	NO_2-NO_3 Nitrogen as N Max. (mg/1)
7	0.722	0.922	1.357	0.540	0.708	0.906	0.898	0.930	1.008
8	0.909	1.025	1.195	0.708	0.943	1.458	0.828	0.882	0.930
9	0.933	1.045	1.202	0.798	1.043	1.350	0.850	0.895	1.350
10	0.981	1.098	1.258	0.720	1.069	1.326	0.670	0.708	0.793
11	0.744	0.822	0.883	0.618	0.852	1.482	0.622	0.671	0.720
12	0.551	0.633	0.732	0.534	0.850	1.254	0.695	0.656	0.675
13	0.508	0.630	0.837	0.510	0.779	1.038	0.651	0.680	0.696
14	0.234	0.317	0.390	0.162	0.452	0.738	0.705	0.729	0.730
15	0.106	0.164	0.238	0.270	0.372	0.546	0.686	0.716	0.768

Table B-12

SUMMARY OF STREAM SURVEY DATA
LITTLE PATUXENT RIVER BASIN

March 20-24, 1967
Chesapeake Field Station

Station Number	Temperature			BOD			DO		
	Min. (Deg.C)	Mean (Deg.C)	Max. (Deg.C)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)
L1	3.0	3.70	5.0	2.7	3.2	3.5	11.4	11.9	12.2
L2	2.8	3.6	5.0	2.7	2.9	3.3	11.5	12.3	12.8
L3	3.0	3.58	4.8	1.8	2.6	3.6	11.6	12.4	12.8
L4	3.0	4.6	7.0	2.5	2.9	3.1	11.7	12.6	13.3
L5	3.0	5.5	7.0	1.3	2.2	2.6	11.5	12.3	12.8
L6	2.0	3.625	5.0	2.1	2.5	3.1	11.9	12.6	12.9
L7	2.0	4.4	7.0	2.4	2.9	3.4	12.4	13.1	13.6

Table B-12 (Continued)

Station Number	Total Phosphorus as PO_4 Min. (mg/l)	Mean (mg/l)	Max. (mg/l)	Total Kjeldahl Nitrogen as N Min. (mg/l)	Mean (mg/l)	Max. (mg/l)	NO_2-NO_3 Nitrogen as N Min. (mg/l)	Mean (mg/l)	Max. (mg/l)
L1	0.797	0.916	1.059	0.510	0.757	0.978	0.980	1.053	1.145
L2	0.603	0.671	0.746	0.450	0.623	0.828	1.060	1.075	1.090
L3	0.354	0.500	0.626	0.270	0.505	0.786	0.954	1.095	1.195
L4	0.362	0.524	0.740	0.348	0.605	0.876	1.090	1.160	1.223
L5	0.249	0.359	0.571	0.180	0.798	2.178	1.180	1.207	1.239
L6	0.269	0.356	0.502	0.192	0.418	0.564	1.108	1.207	1.255
L7	0.092	0.302	0.344	0.066	0.357	0.628	1.090	1.242	1.374

Table B-13

SUMMARY OF STREAM SURVEY DATA
PATUXENT RIVER BASIN

July 31, August 1 & 2, 1967
Chesapeake Field Station

Station Number	Temperature			BOD			DO		
	Min. (Deg.C)	Mean (Deg.C)	Max. (Deg.C)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)
5	24.5	26.3	28.5	3.0	4.7	7.9	5.3	7.1	9.3
6	22.5	23.6	24.8	2.5	3.9	5.7	5.6	6.0	6.7
7	23.2	23.9	24.8	2.4	3.4	5.0	4.9	5.7	6.4
8	22.7	23.7	24.8	3.7	3.9	4.6	4.1	5.2	6.0
9	23.0	23.6	25.0	3.0	5.2	8.5	3.9	4.8	5.9
10	22.5	23.2	24.5	2.7	6.0	8.5	2.0	3.1	4.0
11	22.0	22.6	23.3	2.2	3.3	4.2	4.8	5.8	6.7
12	21.0	22.3	23.4	4.3	4.7	4.8	3.3	4.1	5.4
12A	21.0	22.08	23.0	3.4	4.1	4.8	3.6	4.4	5.2
12B	21.0	21.9	22.5	8.4	9.0	11.0	3.0	3.6	4.2
13	21.5	21.7	22.5	7.2	14.5	19.0	2.6	3.4	4.0
13A	21.0	22.03	22.7	10.2	12.0	18.0	3.7	4.3	4.9
13B	20.5	21.9	22.7	N.G.	N.G.	N.G.	4.5	4.6	4.8
14	20.5	21.8	23.0	3.3	12.0	16.0	5.5	6.1	6.6
14A	20.5	21.4	22.5	3.9	12.0	22.0	5.4	5.9	6.5
15	17.5	20.03	21.5	1.9	2.9	4.2	5.5	8.0	9.1

Table B-13 (Continued)

Station Number	Total Phosphorus as PO_4 Min. (mg/1)	Mean (mg/1)	Max. (mg/1)	Total Kjeldahl Nitrogen as N Min. (mg/1)	Mean (mg/1)	Max. (mg/1)	NO_2-NO_3 Nitrogen as N Min. (mg/1)	Mean (mg/1)	Max. (mg/1)
5	1.147	1.249	1.453	0.564	0.768	0.912	1.990	2.142	2.396
6	1.893	2.003	2.223	0.515	0.628	0.708	1.843	2.261	2.720
7	1.893	2.2436	2.734	0.441	0.625	0.780	1.020	1.595	2.005
8	2.630	2.9516	3.489	0.821	0.908	0.962	1.900	2.547	3.696
9	2.947	3.6073	4.191	1.079	1.286	1.390	2.260	2.486	2.760
10	6.210	6.9726	7.368	0.742	1.618	2.243	2.430	2.980	3.320
11	3.368	3.966	4.425	0.496	0.927	1.716	1.743	2.983	4.682
12	4.946	4.999	5.052	0.529	1.024	1.483	2.550	2.864	3.302
12A	4.105	4.789	5.211	0.374	0.888	1.434	2.095	2.418	2.920
12B	4.736	5.8086	6.946	1.183	2.163	2.807	1.792	2.424	3.100
13	5.157	5.983	7.262	1.852	2.678	3.303	1.760	1.971	2.226
13A	5.788	6.8616	8.841	1.839	3.483	5.012	1.900	2.280	2.560
13B	5.744	5.844	6.000	2.041	2.437	2.690	1.940	2.196	2.450
14	0.244	0.7866	1.188	0.950	1.044	1.183	0.638	0.814	1.145
14A	0.313	0.508	0.691	0.268	0.659	0.932	0.564	0.630	0.726
15	0.084	0.1056	0.131	0.843	1.198	1.692	0.233	0.427	0.540

Table B-14

SUMMARY OF STREAM SURVEY DATA
LITTLE PATUXENT RIVER BASIN

July 31, August 1 & 2, 1967
Chesapeake Field Station

Station Number	Temperature			BOD			DO		
	Min. (Deg.C)	Mean (Deg.C)	Max. (Deg.C)	Min. (mg/l)	Mean (mg/l)	Max. (mg/l)	Min. (mg/l)	Mean (mg/l)	Max. (mg/l)
L1	22.0	23.2	24.5	3.6	4.6	6.7	4.6	5.1	5.6
L2	23.5	24.3	25.5	3.5	5.5	10.0	5.9	6.9	7.9
L3	23.0	24.1	25.0	2.4	3.8	6.1	5.2	7.1	8.4
L4	23.3	24.3	25.5	5.6	6.6	8.1	6.0	7.0	7.8
L5	22.5	23.8	25.5	2.2	3.3	5.6	7.5	8.2	9.4
L6	23.0	24.3	26.0	2.9	3.9	5.2	6.2	7.0	7.3
L7A	23.5	25.06	27.0	2.5	4.4	11.2	9.0	9.6	10.5
L7	23.8	25.5	27.0	1.7	3.3	6.5	8.1	9.1	10.0

Table B-14 (Continued)

Station Number	Total Phosphorus as PO_4 Min. (mg/l)	Total Phosphorus as PO_4 Mean (mg/l)	Total Phosphorus as PO_4 Max. (mg/l)	Total Kjeldahl Nitrogen as N Min. (mg/l)	Total Kjeldahl Nitrogen as N Mean (mg/l)	Total Kjeldahl Nitrogen as N Max. (mg/l)	NO_2-NO_3 Nitrogen as N Min. (mg/l)	NO_2-NO_3 Nitrogen as N Mean (mg/l)	NO_2-NO_3 Nitrogen as N Max. (mg/l)
L1	3.617	4.503	6.104	1.093	1.159	1.256	2.020	2.682	3.758
L2	2.420	2.8883	3.298	1.017	1.531	2.179	1.633	1.974	2.460
L3	1.294	1.5566	1.734	0.701	0.883	0.999	0.970	1.500	1.990
L4	1.558	1.6763	1.808	1.051	1.129	1.263	1.100	1.348	1.672
L5	0.873	0.889	0.906	0.428	0.555	0.637	0.894	0.701	1.280
L6	1.063	2.444	4.558	0.919	1.136	1.425	0.580	0.761	0.870
L7A	0.581	0.765	0.938	0.251	0.264	0.279	0.756	1.008	1.394
L7	0.113	0.137	0.167	0.227	0.277	0.341	0.732	0.766	0.966

Table B-15

SUMMARY OF STREAM SURVEY DATA
PATUXENT RIVER BASIN

September 6,7, & 8, 1967
Chesapeake Field Station

Station Number	Temperature			BOD			DO		
	Min. (Deg.C)	Mean (Deg.C)	Max. (Deg.C)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)
5	18.5	20.3	22.5	1.98	4.28	9.06	5.82	6.43	7.05
7	18.0	19.1	20.0	1.78	3.96	6.72	6.16	6.83	7.05
8	18.0	19.2	21.0	2.56	4.48	6.26	6.12	6.34	6.62
9	17.8	19.4	20.5	3.16	6.04	7.64	6.44	6.68	6.94
10	18.0	19.8	21.5	2.46	6.32	9.88	6.22	6.42	6.67
11	17.5	18.5	19.5	1.12	3.96	7.28	6.58	6.85	7.01
12	17.5	18.6	20.1	2.32	4.28	7.00	6.14	6.44	6.68
13	18.5	19.2	20.0	1.02	4.85	8.82	6.03	6.56	7.30
14	17.8	19.1	21.2	1.72	3.19	8.20	7.16	7.54	7.70
15	18.0	19.6	22.0	0.66	2.44	4.90	7.36	7.62	7.71

Table B-15 (Continued)

Station Number	Total Phosphorus as PO_4			Total Kjeldahl Nitrogen as N		
	Min. (mg/l)	Mean (mg/l)	Max. (mg/l)	Min. (mg/l)	Mean (mg/l)	Max. (mg/l)
5	0.777	0.847	0.988	0.523	0.753	0.968
7	1.168	1.349	1.564	0.726	0.850	0.939
8	1.359	1.951	3.064	0.787	1.070	1.268
9	1.691	2.031	2.223	1.085	1.372	1.563
10	1.766	1.971	2.106	0.951	1.032	1.143
11	1.168	1.332	1.585	0.543	0.732	0.099
12	1.811	1.829	1.840	0.480	0.732	0.980
13	2.170	2.482	2.644	1.018	1.259	1.616
14	0.116	0.255	0.329	0.329	0.406	0.534
15	0.087	0.114	0.195	0.443	0.455	0.465

Table B-16

SUMMARY OF STREAM SURVEY DATA
LITTLE PATUXENT RIVER BASIN

September 6,7, & 8, 1967
Chesapeake Field Station

Station Number	Temperature			BOD			DO		
	Min. (Deg.C)	Mean (Deg.C)	Max. (Deg.C)	Min. (mg/l)	Mean (mg/l)	Max. (mg/l)	Min. (mg/l)	Mean (mg/l)	Max. (mg/l)
L1	18.0	19.2	20.5	3.30	5.24	9.82	6.06	6.85	7.01
L2	18.0	19.7	21.0	2.48	4.80	5.64	6.16	6.95	8.11
L3	17.5	19.4	20.5	1.76	2.84	4.12	7.04	7.78	8.34
L4	17.0	18.1	19.5	1.50	4.29	9.00	7.48	7.78	8.10
L5	16.0	17.4	19.2	0.74	4.36	14.70	8.04	8.82	9.28
L6A	17.0	18.3	20.9	1.52	8.65	34.50	3.12	4.32	5.25
L7	15.5	17.7	20.5	0.16	2.60	4.68	9.05	9.65	10.62

Table B-16 (Continued)

Station Number	Total Phosphorus as PO_4 Min. (mg/l)	Mean (mg/l)	Max. (mg/l)	Total Kjeldahl Nitrogen as N Min. (mg/l)	Mean (mg/l)	Max. (mg/l)
L1	2.074	2.129	2.202	1.006	1.073	1.151
L2	2.213	2.532	2.957	1.378	1.673	2.105
L3	0.457	1.048	1.415	0.597	0.693	0.823
L4	1.064	1.173	1.234	0.597	0.636	0.665
L5	0.819	0.836	0.860	0.213	0.365	0.455
L6A	1.787	3.257	5.776	1.883	3.077	5.384
L7	0.087	0.103	0.112	0.030	0.176	0.333

Table B-17

SUMMARY OF STREAM SURVEY DATA
PATUXENT RIVER BASIN

October 23,24, & 25, 1967
Chesapeake Field Station

Station Number	Temperature			BOD			DO		
	Min. (Deg.C)	Mean (Deg.C)	Max. (Deg.C)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)
5	11.5	11.8	12.5	1.7	3.2	4.3	.8	6.7	8.0
7	9.5	10.4	11.8	2.3	2.9	3.6	5.4	6.5	7.4
8	10.0	10.8	12.5	3.5	4.1	5.3	5.9	7.0	8.3
9	9.9	10.4	11.5	4.4	5.1	6.6	5.5	6.5	7.3
10	10.5	11.2	12.6	3.3	7.7	16.0	4.5	5.3	6.2
11	10.0	10.8	12.0	2.4	3.0	4.0	5.6	5.9	6.3
12	10.0	10.9	12.5	3.1	5.3	8.9	4.2	5.1	6.3
13	11.2	12.1	13.8	3.6	6.9	11.0	3.9	5.0	6.4
14	12.0	12.7	14.0	1.4	2.6	4.2	6.4	7.6	9.0
15	12.5	13.7	15.1	1.4	3.1	4.8	6.5	8.3	11.2

Table B-17 (Continued)

Sta. No.	Total Phosphorus as PO_4 Min. (mg/l)	Total Phosphorus as PO_4 Mean (mg/l)	Total Phosphorus as PO_4 Max. (mg/l)	Coliform Min. (MPN/100 ml)	Coliform Mean (MPN/100 ml)	Coliform Max. (MPN/100 ml)	E. coli Min. (MPN/100 ml)	E. coli Mean (MPN/100 ml)	E. coli Max. (MPN/100 ml)
5	1.701	2.214	2.500	430	4,200	7,500	230	1,150	2,300
7	3.031	3.285	3.496	90	160	230	40	80	90
8	3.802	4.020	4.140	40	170	230	40	100	230
9	3.719	4.279	4.806	90	200	290	40	60	90
10	7.917	8.552	9.373	150	890	2,300	20	90	210
11	4.827	5.046	5.208	20	180	430	20	50	90
12	6.292	7.001	7.848	210	460	930	90	120	150
13	6.833	7.834	9.265	230	330	390	40	120	230
14	1.081	1.182	1.331	430	1,050	2,300	70	250	430
15	0.128	0.157	0.173	43,000	125,000	240,000	4,300	7,630	9,300

Table B-18

SUMMARY OF STREAM SURVEY DATA LITTLE PATUXENT RIVER BASIN

October 23,24, & 25, 1967
Chesapeake Field Station

Station Number	Temperature			BOD			DO		
	Min. (Deg.C)	Mean (Deg.C)	Max. (Deg.C)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)	Min. (mg/1)	Mean (mg/1)	Max. (mg/1)
L1	9.0	10.3	12.0	0.5	3.7	5.4	5.4	7.3	8.7
L2	10.0	11.0	13.2	3.4	4.8	6.2	6.3	7.7	8.8
L2A	8.5	10.1	12.5	2.5	3.3	4.0	6.9	8.6	9.5
L3	9.0	10.3	12.0	1.5	2.7	3.3	7.5	8.6	9.4
L4	10.0	11.2	13.5	2.7	4.4	6.3	7.6	9.3	10.3
L5	9.8	10.5	12.0	1.0	1.9	3.0	8.3	9.9	10.9
L6A	12.5	13.6	15.5	3.4	6.1	10.0	2.9	6.3	10.9
L7A	10.0	11.1	13.0	0.5	1.0	1.5	8.9	10.2	10.9
L7B	10.2	11.7	13.0	0.5	1.5	2.8	6.8	9.2	11.7
L7	10.5	11.3	13.0	0.5	1.5	2.3	8.3	10.3	11.6

Table B-18 (Continued)

Sta. No.	Total Phosphorus as PO_4 Min. (mg/l)	Mean (mg/l)	Max. (mg/l)	Coliform Min. (MPN/100 ml)	Mean (MPN/100 ml)	Max. (MPN/100 ml)	E. coli Min. (MPN/100 ml)	Mean (MPN/100 ml)	Max. (MPN/100 ml)
L1	3.062	3.396	3.600	150	200	230	40	120	230
L2	2.271	2.827	3.254	210	910	2,300	70	200	430
L2A	1.167	1.226	1.268	43,000	76,000	93,000	43,000	59,660	93,000
L3	1.135	1.372	1.546	230	530	930	40	120	230
L4	1.917	2.207	2.476	3	30	70	10	20	20
L5	0.667	1.476	2.800	230	430	930	20	70	150
L6A	3.021	3.712	4.320	2,300	2,900	4,300	230	470	750
L7A	0.517	0.752	0.957	210	466	930	90	140	230
L7B	4.260	4.611	4.817	70	410	930	40	100	150
L7	0.130	0.138	0.142	210	360	430	150	180	230

Table B-19

RECENT AND/OR CURRENT WATER QUALITY STUDIES, SURVEYS, AND RESEARCH ACTIVITIES

Agency	Study	Type of Study or Surveys
Natural Resources Institute, University of Maryland	Patuxent Thermal Study	Pollution ecology in Patuxent Estuary
" " "	Fish Funa Survey of the Upper Patuxent River	Evaluation of the effects of pollution on fish
Department of Water Resources, State of Maryland	Patuxent Thermal Surveys	Physical, chemical, and biological surveys
" " "	Patuxent River Surveys	Physical, chemical, and biological surveys
" " "	Patuxent Estuary Simulation Study	Water quality simulation
Academy of Natural Sciences of Philadelphia	Patuxent River Stream Surveys and Study	Pollution ecology in Patuxent Estuary
Geological Survey, U.S. Department of the Interior	Patuxent Estuary Surveys	Water quality monitoring in Patuxent Estuary
" " "	Epifauna Study in the Patuxent Estuary	Pollution ecology study of attached organisms in the Patuxent Estuary
Chesapeake Field Station, Federal Water Pollution Control Administration	Patuxent River Biological Survey	A survey of the benthic organisms in the upper and middle reaches
" " "	Water Quality and Pollution Control Surveys and Study of the Patuxent River	An assessment of water quality management needs in the upper basin

Table B-19 (Continued)

Agency	Study	Type of Study or Surveys
Chesapeake Field Station, Federal Water Pollution Control Administration	Patuxent River Nutrient Study	A study of the nutrient and algal production relationships in the estuary
" " "	Patuxent Estuary Thermal Surveys	Thermal monitoring of the Patuxent Estuary

Table B-20

MEANS AND EXTREMES OF SURFACE WATER TEMPERATURES*IN THE PATUXENT ESTUARY AT SOLOMONS, MARYLAND

Month	Temperature C°		
	Minimum	Average	Maximum
January	-0.6	3.5	9.4
February	-0.8	3.3	8.1
March	0.8	6.1	14.4
April	5.6	11.5	18.3
May	11.2	18.0	24.3
June	18.8	23.5	29.6
July	21.9	26.5	31.0
August	22.9	26.7	30.2
September	17.8	24.0	28.0
October	12.9	18.3	25.7
November	6.3	12.4	18.5
December	1.5	6.1	12.1

---

* Reference (   )

Table B-21

POTENTIAL STRUCTURE LOCATIONS IN THE MIDDLE PATUXENT WATERSHED

Site	Description
1 A	Located on an unnamed tributary of the Middle Patuxent southeast of Clarksville, Maryland (D.A. = 5.2 square miles)
2	Located on an unnamed tributary of the Middle Patuxent just north of Maryland Route 108 (D.A. = 9.0 square miles)
3	Located on the Middle Patuxent approximately 4,000 feet west of Route 32 and just south of the National Pike (D.A. = 8.9 square miles)

Table B-22

LOW-FLOW AUGMENTATION POTENTIAL FOR WATER QUALITY CONTROL IN THE MIDDLE PATUXENT WATERSHED

Plan No.	Flow (cfs)	Storage Required for Water Quality Control (acre feet)	Site No.	Storage Available for Water Quality Control at Site (acre feet)	Cost of Storage ($1000)	Total Cost of Plan ($1000)
1	25	2000	3	2000	$225	$225
2	35	3900	2	1900	200	
			3	2000	225	420
3	45	5700	1A	1300	135	
			2	2200	220	
			3	2200	240	595
4	45	5700	2	2900	270	
			3	2800	290	560

APPENDIX C

TABLE C-1

Plans A, B, C, and D
Secondary System Modular Cost
For The Years
1970 - 2000

		Secondary System			Treatment Cost		Pres. Worth Cost 1970		Total Pres. Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd) D	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal) B	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-00 ($1000)
Maryland City	1970-1980	0.75	1.50	2.25	0.75	0.075	750	490	1,240	-
	1980-2000	-	0.75	3.00	0.50	0.065	-	-	-	-
	1980-2000	-	-	-	-	-	320	600	-	920
Laurel Parkway	1970-1980	2.4	4.0	6.4	1.50	0.056	1,500	1,040	2,540	-
	1980-2000	-	3.5	9.9	1.40	0.050	-	-	-	-
	1980-2000	-	-	-	-	-	900	1,510	-	2,110
Bowie Horsepen	1970-1980	0.0	2.0	2.0	0.92	0.072	920	420	1,340	-
	1980-2000	-	2.0	4.0	0.92	0.062	-	-	-	-
	1980-2000	-	-	-	-	-	590	760	-	1,350
Bowie - Belair	1970-1980	2.2	1.5	3.7	0.75	0.062	750	660	1,410	-
	1980-2000	-	1.5	5.5	0.75	0.058	-	-	-	-
	1980-2000	-	-	-	-	-	480	920	-	1,400
Savage	1970-1980	1.0	7.0	8.0	3.80	0.052	3,800	1,200	5,000	-
	1980-2000	-	7.0	15.0	3.80	0.045	-	-	-	-
	1980-2000	-	-	-	-	-	2,440	2,060	-	4,500
Fort George Meade #2	1970-1980	2.5	0.0	2.5	0.00	0.070	000	450	450	-
	1980-2000	-	0.0	2.5	0.00	0.070	-	-	-	-
	1980-2000	-	-	-	-	-	000	535	-	535
Fort George Meade #1	1970-1980	1.5	0.0	1.5	0.00	0.076	000	330	330	-
	1980-2000	-	1.5	3.0	0.75	0.065	-	-	-	-
	1980-2000	-	-	-	-	-	480	600	-	1,080

TABLE C-1 (CONTINUED)

Plans A, B, C, and D
Secondary System Modular Cost
For The Years
1970 - 2000

		Secondary System			Treatment Cost		Pres. Worth Cost 1970		Total Pres. Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd) D	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal) B	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-00 ($1000)
Patuxent	1970-1980	2.5	2.0	4.5	0.92	0.060	920	780	1,700	-
	1980-2000	-	1.5	6.0	0.75	0.056	-	-	-	-
	1980-2000	-	-	-	-	-	480	530	-	1,010
Western Br.	1970-1980	0.0	8.0	8.0	4.20	0.052	4,200	1,200	5,400	-
	1980-2000	-	8.0	16.0	4.20	0.046	-	-	5,400	-
	1980-2000	-	-	-	-	-	2,120	2,250	-	4,370
							20,650	16,335	19,410	17,575
							36,985		36,985	

TABLE C-2

Plan A - Coagulation and Sedimentation Modular Cost
For The Years
1970 - 2000

Name	Operating Years	Coagulation & Sedimentation			Treatment Cost		Pres. Worth Cost 1970		Total Pres. Costs	
		Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-00 ($1000)
Maryland City	1970-1980	0.0	2.5	2.5	0.11	0.030	110	220	330	-
	1980-2000	-	0.5	3.0	0.05	0.030	-	-	-	-
	1980-2000	-	-	-	-	-	30	270	-	300
Laurel Parkway	1970-1980	0.0	6.4	6.4	0.27	0.028	270	520	790	-
	1980-2000	-	3.5	9.9	0.15	0.028	-	-	-	-
	1980-2000	-	-	-	-	-	100	850	-	950
Bowie Horsepen	1970-1980	0.0	2.0	2.0	0.09	0.030	90	170	260	-
	1980-2000	-	2.0	4.0	0.09	0.029	-	-	-	-
	1980-2000	-	-	-	-	-	60	350	-	410
Bowie - Belair	1970-1980	0.0	4.0	4.0	0.17	0.029	170	330	500	-
	1980-2000	-	1.5	5.5	0.05	0.028	-	-	-	-
	1980-2000	-	-	-	-	-	30	450	-	480
Savage	1970-1980	0.0	8.0	8.0	0.42	0.028	420	640	1,060	-
	1980-2000	-	7.0	15.0	0.28	0.027	-	-	-	-
	1980-2000	-	-	-	-	-	180	1,240	-	1,420
Fort George Meade #2	1970-1980	0.0	2.5	2.5	0.11	0.030	110	220	330	-
	1980-2000	-	0.0	2.5	0.00	0.030	-	-	-	-
	1980-2000	-	-	-	-	-	00	230	-	230
Fort George Meade #1	1970-1980	0.0	1.5	1.5	0.07	0.030	70	130	200	-
	1980-2000	-	1.5	3.0	0.07	0.030	-	-	-	-
	1980-2000	-	-	-	-	-	40	275	-	315

TABLE C-2 (CONTINUED)

Plan A - Coagulation and Sedimentation Modular Cost
For The Years
1970 - 2000

		Coagulation & Sedimentation			Treatment Cost		Pres. Worth Cost 1970		Total Pres. Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-00 ($1000)
Patuxent	1970-1980	0.0	5.0	5.0	0.22	0.029	220	420	640	-
	1980-2000	-	1.0	6.0	0.05	0.029	-	-	-	-
	1980-2000	-	-	-	-	-	30	530	-	560
Western Br.	1970-1980	0.0	8.0	8.0	0.32	0.028	320	640	960	-
	1980-2000	-	8.0	16.0	0.32	0.027	-	-	-	-
	1980-2000	-	-	-	-	-	200	1,320	-	1,520
							2,450	8,805	5,070	6,185

TABLE C-3

Plan A - Ammonia Stripping Modular Cost
For The Years
1970 - 2000

Name	Operating Years	Ammonia Stripping Process			Treatment Cost		Pres. Worth Cost 1970		Total Pres. Costs	
		Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-00 ($1000)
Maryland City	1970-1980	0.0	2.5	2.5	0.12	0.012	120	90	210	-
	1980-2000	-	0.5	3.0	0.08	0.012	-	-	-	-
	1980-2000	-	-	-	-	-	50	110	-	160
Laurel Parkway	1970-1980	0.0	6.4	6.4	0.22	0.011	220	205	425	-
	1980-2000	-	3.5	9.9	0.18	0.011	-	-	-	-
	1980-2000	-	-	-	-	-	110	330	-	440
Bowie Horsepen	1970-1980	0.0	2.0	2.0	0.11	0.012	110	70	180	-
	1980-2000	-	2.0	4.0	0.11	0.011	-	-	-	-
	1980-2000	-	-	-	-	-	70	130	-	200
Bowie - Belair	1970-1980	0.0	4.0	4.0	0.16	0.011	160	130	290	-
	1980-2000	-	1.5	5.5	0.09	0.011	-	-	-	-
	1980-2000	-	-	-	-	-	60	170	-	230
Savage	1970-1980	0.0	8.0	8.0	0.26	0.011	260	250	510	-
	1980-2000	-	7.0	15.0	0.24	0.010	-	-	-	-
	1980-2000	-	-	-	-	-	160	450	-	610
Fort George Meade #2	1970-1980	0.0	2.5	2.5	0.12	0.012	120	85	205	-
	1980-2000	-	0.0	2.5	0.00	0.012	-	-	-	-
	1980-2000	-	-	-	-	-	-	90	-	90
Fort George Meade #1	1970-1980	0.0	1.5	1.5	0.09	0.014	90	60	150	-
	1980-2000	-	1.5	3.0	0.09	0.012	-	-	-	-
	1980-2000	-	-	-	-	-	60	110	-	170

TABLE C-3 (CONTINUED)

Plan A - Ammonia Stripping Modular Cost
For The Years
1970 - 2000

Name	Operating Years	Ammonia Stripping Process			Treatment Cost		Pres. Worth Cost 1970		Total Pres. Costs	
		Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-00 ($1000)
Patuxent	1970-1980	0.0	3.0	5.0	0.17	0.011	170	150	320	-
	1980-2000	-	1.0	6.0	0.09	0.011	-	-	-	-
	1980-2000	-	-	-	-	-	60	200	-	260
Western Br.	1970-1980	0.0	8.0	8.0	0.26	0.011	260	250	510	-
	1980-2000	-	8.0	16.0	0.26	0.010	-	-	-	-
	1980-2000	-	-	-	-	-	170	490	-	660
							2,250	3,370	2,800	2,820

TABLE C-4

Plan A - Rapid Sand Filtration Modular Cost
For The Years
1970 - 2000

		Filtration			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
Maryland City	1970-1980	0.0	2.5	2.5	0.16	0.044	160	320	480	-
	1980-2000	-	0.5	3.0	0.06	0.042	-	-	-	-
	1980-2000	-	-	-	-	-	40	385	-	425
Laurel Parkway	1970-1980	0.0	6.4	6.4	0.29	0.030	290	550	840	-
	1980-2000	-	3.5	9.9	0.20	0.027	-	-	-	-
	1980-2000	-	-	-	-	-	130	820	-	950
Bowie-Horsepen	1970-1980	0.0	2.0	2.0	0.14	0.047	140	270	410	-
	1980-2000	-	2.0	4.0	0.14	0.037	-	-	-	-
	1980-2000	-	-	-	-	-	90	450	-	540
Bowie-Belair	1970-1980	0.0	4.00	4.0	0.22	0.037	220	430	650	-
	1980-2000	-	1.50	5.5	0.09	0.034	-	-	-	-
	1980-2000	-	-	-	-	-	60	540	-	600
Savage	1970-1980	0.0	8.0	8.0	0.350	0.027	350	625	975	-
	1980-2000	-	7.0	15.0	0.330	0.023	-	-	-	-
	1980-2000	-	-	-	-	-	210	1055	-	1265
Ft. G. Meade #2	1970-1980	0.0	2.5	2.5	0.16	0.044	160	320	480	-
	1980-2000	-	0	2.5	0.00	0.044	-	-	-	-
	1980-2000	-	-	-	-	-	-	340	-	340
Ft. G. Meade #1	1970-1980	0.0	1.5	1.5	0.12	0.052	120	225	345	-
	1980-2000	-	1.5	3.0	0.12	0.040	-	-	-	-
	1980-2000	-	-	-	-	-	80	370	-	450

TABLE C-4 (Continued)

Name	Operating Years	Filtration			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
		Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
Patuxent	1970-1980	0.0	5.0	5.0	0.260	0.034	260	490	750	-
	1980-2000	-	1.0	6.0	0.090	0.032	-	-	-	-
	1980-2000	-	-	-	-	-	60	590	-	650
Western Branch & Marlboro Meadows	1970-1980	0.0	8.0	8.0	0.350	0.027	350	625	975	-
	1980-2000	-	8.0	16.0	0.350	0.022	-	-	-	-
	1980-2000	-	-	-	-	-	220	1075	-	1295
							2,940	9,480	5,905	6,515
							12,420		12,420	

TABLE C-5

Plan A - Granular Carbon Adsorption Modular Cost
For The Years
1970 - 2000

		Granular Carbon Adsorption Process			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-2000 ($1000)
Maryland City	1970-1980	0.0	2.5	2.5	0.67	0.076	670	550	1220	-
	1980-2000	-	0.5	3.0	0.36	0.073	-	-	-	-
	1980-2000	-	-	-	-	-	240	670	-	910
Laurel Parkway	1970-1980	0.0	6.4	6.5	1.20	0.064	1200	1180	2380	-
	1980-2000	-	3.5	9.9	0.82	0.058	-	-	-	-
	1980-2000	-	-	-	-	-	520	1760	-	2280
Bowie Horsepen	1970-1980	0.0	2.0	2.0	0.58	0.081	580	460	1040	-
	1980-2000	-	2.0	4.0	0.58	0.067	-	-	-	-
	1980-2000	-	-	-	-	-	370	810	-	1180
Bowie Belair	1970-1980	0.0	4.00	4.0	0.90	0.067	900	770	1670	-
	1980-2000	-	1.50	5.5	0.42	0.062	-	-	-	-
	1980-2000	-	-	-	-	-	270	980	-	1250
Savage	1970-1980	0.0	8.0	8.0	1.4	0.056	1400	1290	2690	-
	1980-2000	-	7.0	15.0	1.3	0.048	-	-	-	-
	1980-2000	-	-	-	-	-	840	2200	-	3040
Ft. G. Meade #2	1970-1980	0.0	2.5	2.5	0.67	0.076	670	550	1220	-
	1980-2000	-	0	2.5	0.00	0.076	-	-	-	-
	1980-2000	-	-	-	-	-	-	580	-	580
Ft. G. Meade #1	1970-1980	0.0	1.5	1.5	0.49	0.088	490	380	870	-
	1980-2000	-	1.5	3.0	0.49	0.074	-	-	-	-
	1980-2000	-	-	-	-	-	310	680	-	990

TABLE C-5 (Continued)

		nular Carbon Adsorption Process			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-2000 ($1000)
Patuxent	1970-1980	0.0	5.0	5.0	1.05	0.064	1050	920	1970	-
	1980-2000	-	1.0	6.0	0.36	0.060	-	-	-	-
	1980-2000	-	-	-	-	-	230	1100	-	1330
Western Branch & Marlboro Meadows	1970-1980	0.0	8.0	8.0	1.40	0.056	1400	1290	2690	-
	1980-2000	-	8.0	16.0	1.40	0.048	-	-	-	-
	1980-2000	-	-	-	-	-	900	2350	-	3250
							12,040	18,520	15,750	14,810
							30,560		30,560	

TABLE C-6

Plan B - Coagulation and Sedimentation Modular Cost
For The Years
1970 - 2000

		Coagulation and Sedimentation			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-2000 ($1000)
Maryland City	1970-1980	0.0	To Laurel	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Laurel Parkway	1970-1980	0.0	9.0	9.0	0.38	0.029	380	750	1130	-
	1980-2000	-	4.0	13.0	0.17	0.028	-	-	-	-
	1980-2000	-	-	-	-	-	110	1110	-	1220
Bowie Horsepen	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Patuxent	1970-1980	0.0	To Bowie-Belair	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Savage	1970-1980	0.0	8.0	8.0	0.32	0.029	320	670	990	-
	1980-2000	-	7.0	15.0	0.29	0.028	-	-	-	-
	1980-2000	-	-	-	-	-	190	1280	-	1470
Ft. G. Meade #2	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Ft. G. Meade #1	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-

TABLE C-6 (Continued)

Name	Operating Years	Coagulation and Sedimentation			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
		Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-2000 ($1000)
Bowie-	1970-1980	0.0	14.0	14.0	0.530	0.027	530	1090	1620	-
Belair	1980-2000	-	6.0	20.0	0.250	0.027	-	-	-	-
	1980-2000	-	-	-	-	-	160	1650	-	1810
Western	1970-1980	0.0	8.0	8.0	0.32	0.029	320	670	990	-
Branch	1980-2000	-	8.0	16.0	0.32	0.027	-	-	-	-
	1980-2000	-	-	-	-	-	200	1320	-	1520
							2,210	8,540	4,730	6,020

TABLE C-7

Plan B - Ammonia Stripping Modular Cost
For The Years
1970 - 2000

		Ammonia Stripping Process			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-2000 ($1000)
Maryland City	1970-1980	0.0	To Laurel	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Laurel Parkway	1970-1980	0.0	9.0	9.0	0.29	0.011	290	290	580	-
	1980-2000	-	4.0	13.0	0.15	0.011	-	-	-	-
	1980-2000	-	-	-	-	-	110	440	-	550
Bowie Horsepen	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-		-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Patuxent	1970-1980	0.0	To Bowie-Belair	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Savage	1970-1980	0.0	8.0	8.0	0.27	0.011	270	250	520	-
	1980-2000	-	7.0	15.0	0.24	0.010	-	-	-	-
	1980-2000	-	-	-	-	-	150	460	-	610
Ft. G. Meade #2	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Ft. G. Meade #1	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-

TABLE C-7 **(Continued)**

		Ammonia Stripping Process			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-80 ($1000)	1980-2000 ($1000)
Bowie	1970-1980	0.0	14.0	14.0	0.43	0.010	430	400	830	-
Belair	1980-2000	-	6.0	20.0	0.18	0.010	-	-	-	-
	1980-20000	-	-	-	-	-	120	610	-	730
Western	1970-1980	0.0	8.0	8.0	0.27	0.011	270	250	520	-
Branch &	1980-2000	-	8.0	16.0	0.27	0.010	-	-	-	-
Marlboro	1980-2000	-	-	-	-	-	170	490	-	660
Meadows										
							1,810	3,190	2,450	2,550

Table C-8

Plan B - Rapid Sand Filtration Modular Cost
For The Years
1970 - 2000

		Filtration			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
Maryland City	1970-1980	0.0	To Laurel	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Laurel Parkway	1970-1980	0.0	9.0	9.0	0.380	0.027	380	700	1080	-
	1980-2000	-	4.0	13.0	0.220	0.024	-	-	-	-
	1980-2000	-	-	-	-	-	140	955	-	1095
Bowie-Horsepen	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Patuxent	1970-1980	0.0	To Bowie-Belair	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Savage	1970-1980	0.0	8.0	8.0	0.350	0.028	350	645	995	-
	1980-2000	-	7.0	15.0	0.320	0.023	-	-	-	-
	1980-2000	-	-	-	-	-	210	1055	-	1265
Ft. G. Meade #2	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-

TABLE C-8 (Continued)

		Filtration			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
Ft. G.	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
Meade #1	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Bowie-	1970-1980	0.0	14.0	14.0	0.510	0.023	510	930	1440	-
Belair	1980-2000	-	6.0	20.0	0.290	0.020	-	-	-	-
	1980-2000	-	-	-	-	-	185	1225	-	1410
Western	1970-1980	0.0	8.0	8.0	0.350	0.028	350	645	995	-
Branch	1980-2000	-	8.0	16.0	0.350	0.023	-	-	-	-
	1980-2000	-	-	-	-	-	255	1125	-	1380
							2,380	7,280	4,510	5,150

TABLE C-9

Plan B - Grandular Carbon Adsorption Modular Cost
For The Years
1970 - 2000

		Granular Carbon Adsorption Process			Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
Maryland City	1970-1980	0.0	To Laurel	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Laurel Parkway	1970-1980	0.0	9.0	9.0	1.50	0.054	1500	1400	2900	-
	1980-2000	-	4.0	13.0	0.90	0.050	-	-	-	-
	1980-2000	-	-	-	-	-	580	1980	-	2560
Bowie-Horsepen	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Patuxent	1970-1980	0.0	To Bowie-Belair		-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Savage	1970-1980	0.0	8.0	8.0	1.40	0.056	1400	1290	2690	-
	1980-2000	-	7.0	15.0	1.35	0.048	-	-	-	-
	1980-2000	-	-	-	-	-	870	2200	-	3070
Ft. G. Meade #2	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
Ft. G. Meade #1	1970-1980	0.0	To Patuxent	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-
	1980-2000	-	-	-	-	-	-	-	-	-

TABLE C-9 (Continued)

	Granular Carbon Adsorption Process				Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
Bowie-	1970-1980	0.0	14.0	14.0	1.90	0.048	1900	1940	3840	-
Belair	1980-2000	-	6.0	20.0	1.10	0.042	-	-	-	-
	1980-2000	-	-	-	-	-	710	2570	-	3280
Western	1970-1980	0.0	8.0	8.0	1.40	0.056	1400	1290	2690	-
Branch	1980-2000	-	8.0	16.0	1.40	0.048	-	-	-	-
	1980-2000	-	-	-	-	-	900	2340	-	3240
							9,260	15,010	12,120	12,150

TABLE C-10

Plan C - Coagulation and Sedimentation,
Ammonia Stripping, Rapid Sand Filtration, and
Granular Carbon Adsorption Modular Costs
For The Years
1970 - 2000

					Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($1/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
		Coagulation and Sedimentation								
Bowie-Belair	1970-1980	0.0	30.0	30.0	1.05	0.027	1050	2335	3385	-
	1980-2000	-	17.0	47.0	0.62	0.027	390	-	-	390
	1980-2000	-	-	-	-	-	-	3880	3880	-
Western Branch	1970-1980	0.0	8.0	8.0	0.32	0.029	320	670	-	990
	1980-2000	-	8.0	16.0	0.32	0.027	-	-	-	-
	1980-2000	-	-	-	-	-	200	1320	1520	-
							1,960	8,205	8,785	1,380
		Ammonia Stripping Process								
Bowie-Belair	1970-1980	0.0	30.0	30.0	0.850	0.010	850	865	1715	-
	1980-2000	-	17.0	47.0	0.500	0.010	-	-	-	-
	1980-2000	-	-	-	-	-	320	1435	-	1755
Western Branch	1970-1980	0.0	8.0	8.0	0.27	0.011	370	250	520	-
	1980-2000	-	8.0	16.0	0.27	0.011	-	-	-	-
	1980-2000	-	-	-	-	-	170	490	-	660
							1,610	3,040	2,235	2,415
			Filtration							
Bowie-Belair	1970-1980	0.0	30.0	30.0	0.850	0.017	850	1470	2320	-
	1980-2000	-	17.0	47.0	0.580	0.015	-	-	-	-
	1980-2000	-	-	-	-	-	375	2160	-	2535

TABLE C-10 (Continued)

					Treatment Cost		Present Worth Cost 1970		Total Present Costs	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
		Filtration								
Western Branch	1970-1980	0.0	8.0	8.0	0.350	0.028	350	645	995	-
	1980-2000	-	8.0	16.0	0.350	0.023	-	-	-	1350
	1980-2000	-	-	-	-	-	225	1125	-	1350
							1,800	5,400	3,315	3,885
		Granular Carbon Adsorption Process								
Bowie-Belair	1970-1980	0.0	30.0	30.0	3.10	0.040	3100	3460	6560	-
	1980-2000	-	17.0	47.0	2.20	0.035	-	-	-	-
	1980-2000	-	-	-	-	-	1420	5030	-	6450
Western Branch	1970-1980	0.0	8.0	8.0	1.40	0.056	1400	1290	2690	-
	1980-2000	-	8.0	16.0	1.40	0.048	-	-	-	-
	1980-2000	-	-	-	-	-	900	2340	-	3240
							6,820	12,210	9,250	9,690

TABLE C-11

Plan D - Coagulation and Sedimentation, Ammonia Stripping,
Rapid Sand Filtration, and Granular Carbon Adsorption Modular Costs
For The Years
1970 - 2000

					Treatment Cost		Present Worth Cost 1970		Total Present Cost	
Name	Operating Years	Current Capacity (mgd)	Additional Capacity (mgd)	Total Capacity (mgd)	Capital Cost ($1,000,000)	O & M Cost ($/1000 gal)	Capital Cost ($1000)	O & M Cost ($1000)	1970-1980 ($1000)	1980-2000 ($1000)
		Coagulation and Sedimentation								
Western Branch	1970-1980	0.0	38.0	38.0	1.30	0.026	1300	2850	4150	-
	1980-2000	-	25.0	63.0	0.90	0.026	-	-	-	-
	1980-2000	-	-	-	-	-	600	5000	-	5600
							1,900	7,850	4,150	5,600
		Ammonia Stripping Process								
Western Branch	1970-1980	0.0	38.0	38.0	1.05	0.011	1050	1210	2260	-
	1980-2000	-	25.0	63.0	0.70	0.010	-	-	-	-
	1980-2000	-	-	-	-	-	450	1925	-	2375
							1,500	3,135	2,260	2,375
		Filtration								
Western Branch	1970-1980	0.0	38.0	38.0	1.00	0.016	1000	1750	2750	-
	1980-2000	-	25.0	63.0	0.75	0.013	-	-	-	-
	1980-2000	-	-	-	-	-	500	2500	-	3000
							1,500	4,250	2,750	3,000
		Granular Carbon Adsorption Process								
Western Branch	1970-1980	0.0	38.0	38.0	3.60	0.036	3600	3945	7545	-
	1980-2000	-	25.0	63.0	2.80	0.033	-	-	-	-
	1980-2000	-	-	-	-	-	1800	6355	-	8155
							5,400	10,300	7,545	8,155

TABLE C-12

COST OF CONNECTING INTERCEPTORS FOR PLANS A, B, C, D, AND E

Plan	Inter-ceptor	Design Flows (mgd)	Length (ft)	Slope (ft/ft)	Pipe Diameter (inches)	Pipe Cost ($/ft)	Total Pipe Cost ($1000)	Total Plan Cost ($1000)
A	(None Required)							0
B	a	3.0	11,000	.0018	18	21	231	
	c	4.5	10,000	.0010	24	24	240	
	e	2.5	18,000	.0010	18	21	378	
	f	4.0	18,000	.0010	21	22	396	
	g	10.0	8,000	.0010	33	33	265	
								1,610
C	a	3.0	11,000	.0018	10	21	231	
	b	13.0	35,000	.0010	33	33	1,160	
	c	17.0	10,000	.0010	36	36	360	
	d	15.0	22,000	.0018	36	36	790	
	e	17.5	18,000	.0010	42	49	883	
	f	21.0	18,000	.0010	42	49	885	
	g	27.0	8,000	.0010	48	61	448	
								4,990
D	a	3.0	11,000	.0010	18	21	231	
	b	13.0	35,000	.0010	33	33	1,160	
	c	17.0	10,000	.0010	36	36	360	
	d	15.0	22,000	.0018	36	36	790	
	e	17.5	22,000	.0018	36	36	790	
	f	21.0	18,000	.0010	42	49	885	
	g	27.0	18,000	.0010	48	61	448	
	h	44.0	75,000	.0010	60	100	7,500	
								12,490

TABLE C-13

BAY OUTFALL INTERCEPTOR AND PUMPING COSTS

Interceptor Cost:

Flow	65 mgd @ 2,000
Length	63,500 feet
Design velocity	2-3 fps
Diameter	36 inches
Pipe cost	$36 ($1/ft)
Total cost	$2,300,000

Pumping Cost:

Static pumping head	60 feet
Friction head	110 feet
Total pumping head	170 feet
Cost of electricity	2¢ kilowatt hour
Pump and motor efficiency	65 percent
Cost of pumping	$20/million gallons @ an average flow of 40 mgd or $290,000/year
Operation and maintenance	$4,700,000
Pumps, etc.	500,000
Structures	600,000
Accessory Equipment	200,000

Total Cost of Interceptors and Pumping: $8,300,000